

# ANNALES

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*Annali di Studi istriani e mediterraneei*  
*Annals for Istrian and Mediterranean Studies*  
*Series Historia Naturalis, 13, 2003, 2*





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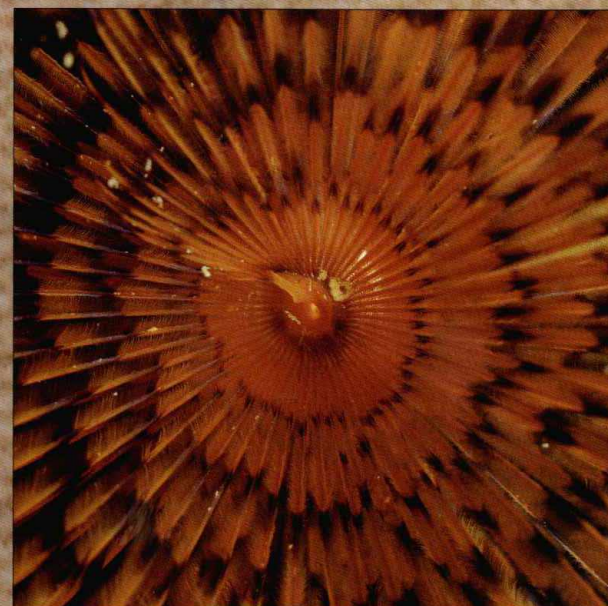
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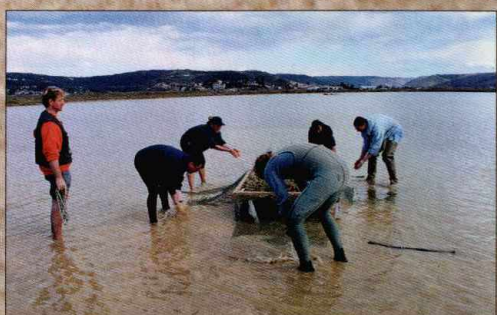




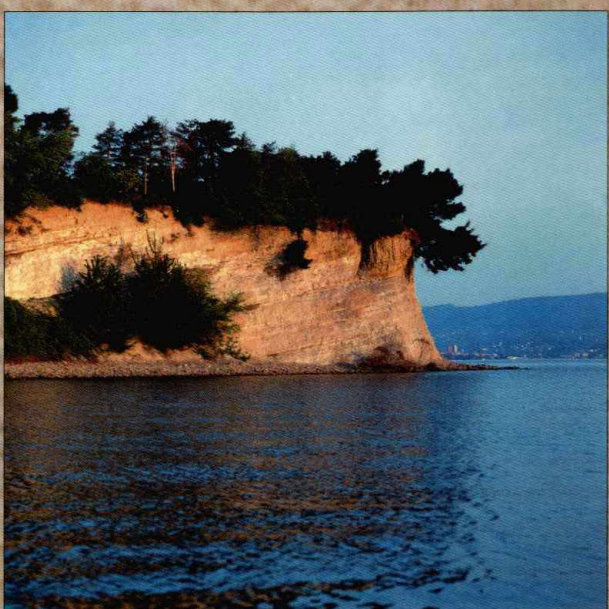
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## LESSEPSIAN FISH MIGRANTS REPORTED IN THE EASTERN ADRIATIC SEA: AN ANNOTATED LIST

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### ABSTRACT

*At least nine Lessepsian fish migrants have been so far recorded in the eastern part of the Adriatic: Pampus argenteus, Hemiramphus far, Paraexocoetus mento, Saurida undosquamis, Sphyræna chrysotaenia, Epinephelus coioides, Leiognathus klunzingeri, Stephanolepis diaspros and Siganus rivulatus. The Adriatic Sea is becoming an area of the Lessepsian migrants' westward distribution path, which has provided us with some important information on their westward spreading.*

**Key words:** ichthyofauna, Lessepsian migration, eastern Adriatic, Mediterranean, Red Sea

## PESCI MIGRANTI LESSEPSIANI RITROVATI IN ADRIATICO ORIENTALE: LISTA INTEGRATA

### SINTESI

*Il ritrovamento di almeno nove specie ittiche lessepsiane è stato fin'ora segnalato nella parte orientale del mare Adriatico: Pampus argenteus, Hemiramphus far, Paraexocoetus mento, Saurida undosquamis, Sphyræna chrysotaenia, Epinephelus coioides, Leiognathus klunzingeri, Stephanolepis diaspros e Siganus rivulatus. Il mare Adriatico sta diventando una delle aree di espansione verso occidente dei migranti lessepsiani e sono state fornite alcune importanti annotazioni e studi riguardo l'espansione verso occidente di nove specie.*

**Parole chiave:** ittiofauna, migrazione lessepsiana, Adriatico orientale, Mediterraneo, Mar Rosso



## INTRODUCTION

According to various marine biological surveys, at least 60 exotic fish species of Indo-Pacific origin have been recorded for the Mediterranean after the opening of the Suez Canal (Orsi Relini, 2001; Golani *et al.*, 2002). Fish and decapod crustaceans as well as molluscs have advanced beyond the limits of the Levant basins. The term "Lessepsian migrant" was coined by Por (1969) to characterize the Red Sea species that have passed through the Suez Canal and settled in the Eastern Mediterranean. The spreading of lessepsian fish migrants has already been recorded for the Aegean and Ionian Seas and considerable numbers have reached the Greek, Turkish and Cyprus coasts (Papaconstantinou, 1990; Golani, 1998, 2000; Corsini & Economidis, 1999; Taskavak *et al.*, 2000; Basusta *et al.*, 2002), while only a few species have been recorded further west and north (Tortonese, 1967; 1970; Papaconstantinou, 1988; also in Golani, 1998; Golani *et al.*, 2002).

Certain changes have been recorded in the Adriatic ichthyofauna, and some Lessepsian fish species were recently reported (in Dulčić *et al.*, 1999; Dulčić & Grbec, 2000; Dulčić *et al.*, 2002; Lipej & Dulčić, *in press*). Owing to the several studies recently carried out in the Adriatic, we now have a fairly accurate overview of the exotic species in this basin. On the basis of the above considerations, the purpose of this paper was to examine the distribution and abundance of Lessepsian migrants (immigrants) in the Adriatic Sea, especially along the eastern coast (Albanian, Montenegrin, Croatian, Slovenian and Italian waters), taking into account some data on their presence and abundance and on the variation of some abiotic parameters in recent years.

## MATERIAL AND METHODS

This study was based mainly on scientific literature and material collected within the framework of research projects conducted by various national research institutions. Other data sources were sports and professional fishermen who have supplied specimens for identification. During this study, data from literature concerning the spreading of Lessepsian migrants in the Mediterranean were also analysed. The greater part of the material is being kept by different Adriatic institutions.

AN ANNOTATED LIST OF LESSEPSIAN MIGRANTS  
IN THE ADRIATIC SEA*Pampus argenteus* (Euphrasen, 1788)

A specimen of butterfish (Stromateidae) was caught off Rijeka (northern Adriatic) in 1896 and was initially identified as *Stromateus fiatola* (Fig. 1). This specimen (Fig. 2), which is kept in the collection of the Zoological

Museum in Zagreb, was identified as *Pampus argenteus* by Šoljan (1948); however, he was doubtful about his identification because *P. argenteus* is an Indo-Pacific species, occurring mainly in South-east Asia and in the East China Sea. Also, Šoljan did not provide any description of the specimen to justify his identification, which remained doubtful until a recent examination of the specimen allowing to confirm Šoljan's provisional identification. It is suggested that the specimen could have entered the Mediterranean Sea by following slow-moving vessels or with pelagic medusae, floating wreckages or drifting seaweed. This record, which dates from 1896, represents the first Lessepsian migrant in the Mediterranean Sea (Dulčić *et al.*, *in press*).

*Hemiramphus far* (Forsskal, 1775)

*Hemiramphus far* is widely distributed in the Indo-Pacific from the Red Sea and east Africa to the Philippines and Samoa (Golani, 2002). In the Mediterranean, it was recorded first in the Eastern Levantine Basin as *H. marginatus* (Steinitz, 1927), and then successively off Syria, Rhodes and Egypt (in Golani *et al.*, 2002). A specimen of this species was also recorded along the Albanian coast (Colette & Parin, 1986).

*Paraexocoetus mento* (Valenciennes, 1846)

*Paraexocoetus mento* is widely distributed in the Indo-Pacific from the Red Sea to Fiji (Golani *et al.*, 2002). In the Mediterranean, it was first recorded in the Eastern Levantine Basin (Bruun, 1935) and then successively in the waters of Rhodes and Libya (in Golani *et al.*, 2002). This species, too, was recorded in Albanian coastal waters (Parin, 1986).

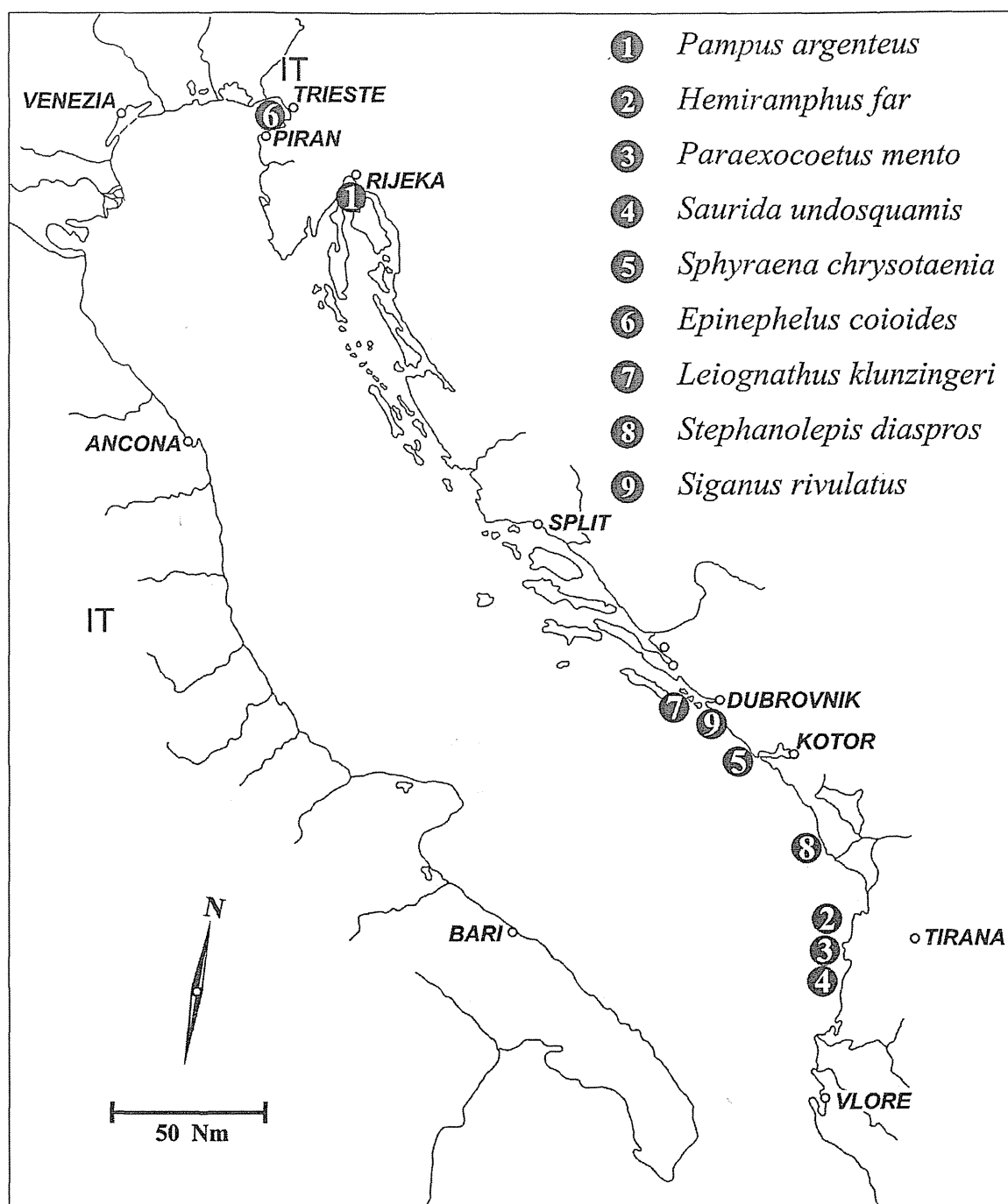
*Saurida undosquamis* (Richardson, 1848)

*Saurida undosquamis* is widely distributed in the Indo-Pacific from the Red Sea and eastern Africa to Australia and southern Japan (Golani *et al.*, 2002). In the Mediterranean, it was first of all recorded in Israel (Ben-Tuvia, 1953) and then successively in the waters of Cyprus, Turkey, Greece, Libya, Dodecaneses, Crete and Egypt (in Golani *et al.*, 2002). It is very important commercial fish, caught by trawl in large quantities in the eastern Basin. A single specimen (28 cm total length) has been recorded off the Albanian coast by Rakaj (1995).

*Sphyraena chrysotaenia* Klunzinger, 1884

The obtuse barracuda *Sphyraena chrysotaenia* has a wide distribution and is found in the eastern Mediterranean (Israel, Lebanon and Egypt), in the Indo-Pacific, from the Red Sea, Persian Gulf and East Africa through-





**Fig. 1: Records of nine Lessepsian migrants found in the Adriatic Sea.**  
**Sl. 1: Podatki o devetih lesepskih migrantih, ugotovljenih v Jadranskem morju.**

out Indian Ocean to Australia and Japan (Ben-Tuvia, 1966). It has also been observed in Turkish waters, from Malta, Eastern Aegean Sea, Western Aegean Sea, Ionian Sea and in the Italian and Tunisian coastlines (Golani, 1998). On 10 August 2000, a 123 mm total length specimen of this species was captured with a small beach seine in the Bay of Gornji Molunat (southern

Adriatic) at a depth of 6 m together with several specimens of *S. sphyraena* (Pallaoro & Dulčić, 2001). The specimen was preserved in formalin and deposited in the collection of the Institute of Oceanography and Fisheries in Split. This is the northernmost record of this species in the Mediterranean area.



***Epinephelus coioides* (Hamilton, 1822)**

The orange-spotted grouper *Epinephelus coioides* occurs in the Red Sea, southwards to (at least) Durban, and eastwards to Ryukyu Islands, Palau, and Fiji (Golani *et al.*, 2002). The first specimen recorded in the Mediterranean Sea was misidentified by Ben-Tuvia & Lourie (1969) as *Epinephelus tauvina*. Another specimen was also caught in Haifa Bay; the local fishermen claimed that this species was caught only on rare occasions (Golani, 1998). It is very rare and only few specimens have been collected in the Mediterranean (Golani *et al.*, 2002). An orange-spotted grouper specimen of 12 cm total length was caught by fishing net on 16 May 1998 about 0.9 km from Trieste, northern Italy, and then maintained at the Civic Marine Aquarium of Trieste (presently the specimen measures 52 cm total length) (Parenti & Bressi, 2001). This is the northernmost record of this species in the Mediterranean Sea.

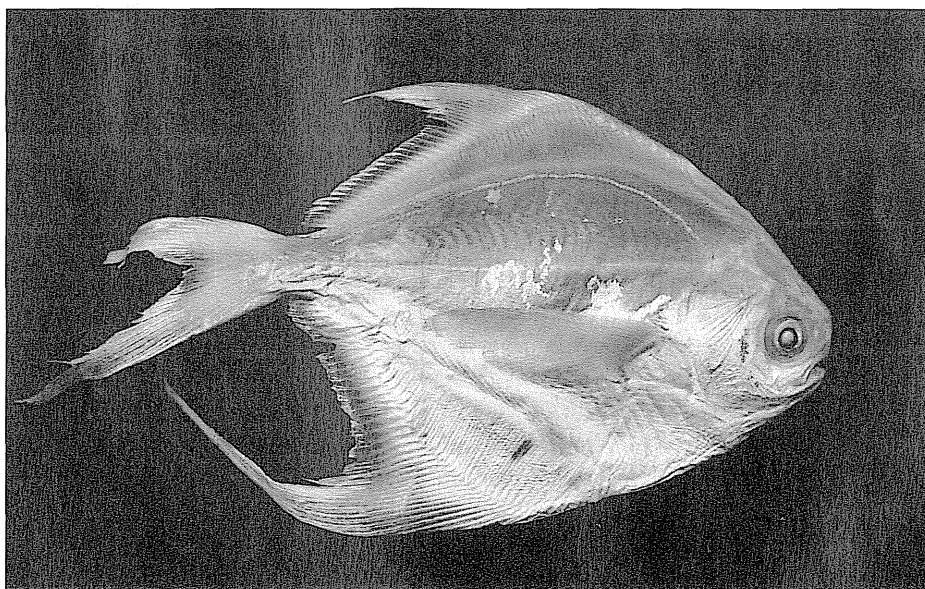
***Leiognathus klunzingeri* (Steindachner, 1898)**

The ponyfish *Leiognathus klunzingeri* has been reported only from the Red Sea, but as *Leiognathus* badly needs taxonomic revision, the distribution range might change (Golani *et al.*, 2002). In the Mediterranean, it was first recorded in Syria (Gruvel, 1931); successively in the waters of Israel, Rhodes, Turkey, Lampedusa Island, NE Greece and Egypt (in Golani *et al.*, 2002). It is very common in the Eastern Mediterranean and caught in large numbers as bycatch in trawl. On 29 June 2000,

an 85 mm total length specimen of ponyfish was captured by beach seine in Saprunara Bay (Mljet Island, southern Adriatic) at a depth of 4 m on sandy bottom (Dulčić & Pallaoro, 2002). It has been deposited in the ichthyological collection of the Institute of Oceanography and Fisheries in Split. This is the northernmost record of this species in the Mediterranean Sea.

***Stephanolepis diaspros* Fraser-Brunner, 1940**

The filefish *Stephanolepis diaspros* has been reported from the Red Sea to the Arabian Gulf (Golani *et al.*, 2002). In the Mediterranean Sea, it was first recorded in the Eastern Levantine Basin (Steinitz, 1927); successively in the waters of Syria, Cyprus, Rhodes, Gulf of Gabes (Tunisia), Gulf of Taranto (Italy), Crete, Saronikos Gulf and Gulf of Palermo (Sicily) (in Golani *et al.*, 2002). It is very common in the Mediterranean Sea. On 23 August 2002, a 77.3 mm total length specimen of *S. diaspros* was found at Ulcinj fish market (southern Adriatic, Montenegro) (Dulčić & Pallaoro, *in press*, a). According to the Ulcinj fishermen, it had been captured with a beach seine in the area of Hrid Đeran, at a depth of about 20 m on the rocky-sandy bottom. The specimen was preserved in formalin and deposited in the ichthyological collection of the Institute of Oceanography and Fisheries in Split (Fig. 3). This is the northernmost record of this species in the Mediterranean area and the first record of a species from the family Monacanthidae for the Adriatic Sea.



**Fig. 2: A specimen of *Pampus argenteus* (Euphrasen, 1788) kept in the Natural History Museum in Zagreb. (Photo: I. Jardaš)**  
**Sl. 2: Primerek vrste *Pampus argenteus* (Euphrasen, 1788), shranjene v zbirki Hrvatskega prirodoslovnega muzeja v Zagrebu. (Foto: I. Jardaš)**

***Siganus rivulatus* Forsskål, 1775**

The rabbitfish *Siganus rivulatus* has been reported from the Red Sea and the Gulf of Aden (Golani *et al.*, 2002). In the Mediterranean, it was first recorded in the Eastern Levantine Basin (Steinitz, 1927); successively in the waters of Syria, Cyprus, Aegean Sea, Libya, Tunisia and Ionian Sea (in Golani *et al.*, 2002). It is very common in the eastern Mediterranean and caught in large quantities by trammel net and purse seine. On 5 October 2000, two specimens of *Siganus rivulatus* (111-149 mm total length) were captured by the beach seine between 07:00 to 09:00 near the islet of Bobara, southern Adriatic (Croatian coast, near Cavtat) at a depth of 15 m on sandy bottom covered by algae and seagrass (Dulčić & Pallaoro, *in press*, b). They were deposited in the Ichthyological Collection of the Institute of Oceanography and Fisheries in Split. This is the northernmost record of this species in the Mediterranean area.

**DISCUSSION**

Up to date, nine Lessepsian migrants (Tab. 1) have reached the Adriatic Sea. The importance of consecutive records in determining the rate of establishment of Lessepsian fish migrant populations cannot be overemphasized. It is natural for first records to be published immediately upon discovery and to receive a great deal of attention. But second and subsequent records can certainly add to our knowledge of a migrant species' establishment. There are seven Lessepsian migrant fish species that have been recorded only as single specimens: *P. argenteus*, *H. far*, *S. undosquamis*, *S. chryso-*

*taenia*, *E. coioides*, *L. klunzingeri* and *S. diaspros*. There have been no data on the number of recorded specimens for the species *P. mento*, while two specimens were observed for *S. rivulatus*. In order to understand whether these records constitute an abortive episode or rather the founder trailblazers of a sustainable population, it is necessary to report consecutive records. In those cases, where subsequent reports include an extension of the species' distribution, it is clear that there will be second and third records as well. There are still no such cases for the Lessepsian fish species found in the Adriatic Sea. However, second and subsequent records that do not extend the distribution often receive less attention and may not necessarily be published (Golani, 2002). Lessepsian fish migrant species may be characterized according to several traits, namely abundance, habitat, feeding habits and size (Golani, 2002).

Nine Lessepsian fish migrants have brought up (together with previous mentioned species in Dulčić *et al.*, 2002) the number of species recorded for the Adriatic to 432 and 122 families. The record of *P. argenteus* dated from 1896 represents the first Lessepsian migrant in the Mediterranean Sea. The occurrence of the orange-spotted grouper *E. coioides* in the Gulf of Trieste (Parenti & Bressi, 2001) is very interesting indeed, since it had been previously recorded only from the coastal waters of Israel and is considered a rare and recent invader (Golani, 1998). Other seven species were amongst the first Eritrean invaders of the Eastern Mediterranean more than thirty years ago, when recorded as common or very common fish species in the Aegean coastal waters and off Anatolian coast (Ben-Tuvia, 1966). Temperature is the most important abiotic factor in deter-

**Tab. 1: List of Lessepsian migrants fished in the Adriatic Sea.**

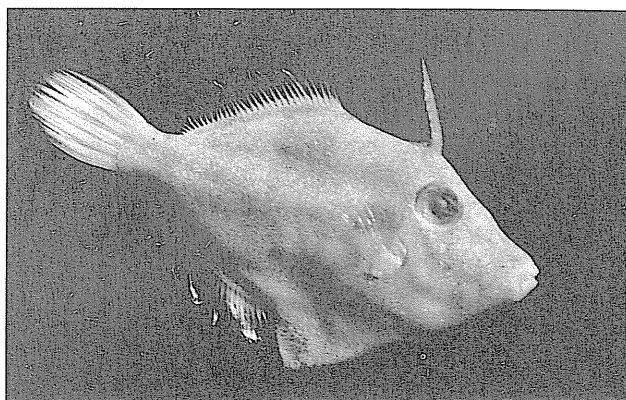
**Legend:** 1 - occurrence: VR - very rare; 2 - habitat: P - pelagic, IP - inshore pelagic, BP - benthopelagic, B - benthic, R - rocky; 3 - feeding habits: FI - feeders of fish and benthic invertebrates, PL - planktivores, BI - benthic invertebrates, H - herbivores; 4 - size: S - small, M - medium; 5 - area: GT - Gulf of Trieste, NA - northern Adriatic, MA - middle Adriatic, SA - southern Adriatic; 6 - first record; 7 - source.

**Tab. 1: Seznam lesepskih selivk, ugotovljenih v Jadranskem morju.**

**Legenda:** 1 - pojavljanje: VR - zelo redko; 2 - habitat: P - pelaški, IP - obalno pelaški, BP - bento-pelaški, B - bentoški, R - skalnati; 3 - prehranjevalne navade: FI - ribe in bentoški nevretenčarji, PL - planktivori, BI - bentoški nevretenčarji, H - rastlinojedi; 4 - velikost: S - majhne, M - srednje velike; 5 - območje: GT - Tržaški zaliv, NA - severni Jadran, MA - srednji Jadran, SA - južni Jadran; 6 - prvi zapis; 7 - vir.

Species	1	2	3	4	5	6	7
<i>Pampus argenteus</i> (Euphrasen, 1788)	VR	P	?	M	NA	1896	Dulčić <i>et al.</i> ( <i>in press</i> )
<i>Hemiramphus far</i> (Forsskål, 1775)	VR	IP	PL	?	SA	?	Collette & Parin (1986)
<i>Paraexocoetus mento</i> (Valenciennes, 1846)	?	IP	PL	?	SA	?	Parin (1986)
<i>Saurida undosquamis</i> (Richardson, 1848)	VR	B	FI	?	SA	?	Rakaj (1995)
<i>Sphyræna chrysotaenia</i> Klunzinger, 1884	VR	BP	FI	M	SA	2000	Pallaoro & Dulčić (2001)
<i>Epinephelus coioides</i> (Hamilton, 1822)	VR	B	FI	M	GT	1998	Parenti & Bressi (2001)
<i>Leiognathus klunzingeri</i> (Steindachner, 1898)	VR	B	BI	S	SA	2000	Dulčić & Pallaoro (2002)
<i>Stephanolepis diaspros</i> Fraser-Brunner, 1940	VR	R	BI	S	SA	2002	Dulčić & Pallaoro ( <i>in press</i> , b)
<i>Siganus rivulatus</i> Forsskål, 1775	VR	B	H	M	SA	2000	Dulčić & Pallaoro ( <i>in press</i> , a)





**Fig. 3:** A specimen of *Stephanolepis diaspros* **Fraser-Brunner, 1940** caught in the waters off **Ulcinj (Montenegro)**. (Photo: **A. Pallaoro**)

**Sl. 3:** **Primerek vrste** *Stephanolepis diaspros* **Fraser-Brunner, 1940**, **ujet v vodah blizu Ulcinja (Črna gora)**. (Foto: **A. Pallaoro**)

mining the dispersal of Lessepsian fish (Golani, 2002). It is not really known what is the impact of the Lessepsian migrant in the Adriatic environment and at this stage it is very hard to perform any direct study to assess possible impact. According to Golani (1993), however, the impact of Lessepsian migration on the Levantine basin ecosystem has been immense. Some authors reported that the diet of Lessepsian predators, such as the brush-tooth lizardfish *S. undosquamis*, consisted mainly of other Lessepsian fish species (*L. klunzingeri*) and Lessepsian crustaceans (Golani, 1993). Golani & Galil (1991) compared the feeding habits of the two indigenous mullets *Mullus barbatus* and *M. surmuletus* to that of the two confamilial Lessepsian migrant *Upeneus mollucensis* and *U. pori*. The authors found a high rate of similarity in the diet of all four species. Golani (1994) showed that niche partitioning of the eastern Mediterranean mullets is achieved on the bathymetrical axis; Lessepsian mullets occupy shallow waters (20-50 m), while indigenous species dominate at greater depths. However, due to lack of knowledge concerning bathymetric distribution of the indigenous mullets in the eastern Levant, prior to the Lessepsian invasion, it cannot be determined whether a habitat displacement has taken place in this region. An opposite trend has been observed regarding lizardfishes (Synodontidae); the indigenous species *Synodus saurus* occupies shallower water than the Lessepsian migrant *S. undosquamis* (Golani, 1993).

Changes in the Adriatic ichthyofauna have been associated with climatic and oceanographic changes (Dulčić *et al.*, 1999; Dulčić & Grbec, 2000; Lipej & Dulčić, *in press*). Oceanographic changes in the Adriatic can be associated with the climate in the Mediterranean; this is a consequence of the changes in distribution of air pressure over the wider Mediterranean, which causes the horizontal air pressure to vary between the northern and southern Adriatic and hence influences the intensity of water exchange between the Adriatic and the eastern Mediterranean (Grbec *et al.*, 1998). Because the incoming Mediterranean water in the Adriatic carries nutrient-rich water that affects primary and secondary production, climate change, via its oceanographic influence, can play an important role in the Adriatic ecosystem. The incoming Ionian water (Adriatic ingression) is also warmer, and many fish species move towards higher latitudes. Therefore, the strong year-to-year changes in sea surface temperatures, which are closely related to climatic fluctuations, can well be responsible for such range extensions. A general summary of the occurrence of fish species in the Adriatic over the last 25 years is that numbers of thermophilous species have increased, that several species, fairly rare or very rare until now, are more abundant, while others are new to the zone (in Dulčić *et al.*, 1999; Dulčić & Grbec, 2000; Lipej & Dulčić, *in press*).

The last decade has witnessed an upsurge of comprehensive studies on the phenomenon of Lessepsian fish migration. The Adriatic Sea is obviously becoming an area of the Lessepsian migrants' westward distribution path, which has provided us with some important information on their westward spreading. We are looking forward to the continuation of this scientific effort and hope for further cooperation amongst ichthyologists of the Levant and Adriatic Sea in the study of Lessepsian migration.

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LESEPSKE RIBJE SELIVKE, UGOTOVLJENE V VZHODNEM JADRANU:  
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## POVZETEK

Na podlagi številnih bioloških raziskav so v Sredozemskem morju ugotovili vsaj 60 vrst ribjih lesepskih selivk po odprtju Sueškega prekopa leta 1869. Doslej je bilo v vzhodnem Jadranskem morju ugotovljenih devet vrst lesepskih selivk: *Pampus argenteus*, *Hemiramphus far*, *Paraexocoetus mento*, *Saurida undosquamis*, *Sphyræna chrysotaenia*, *Epinephelus coioides*, *Leiognathus klunzingeri*, *Stephanolepis diaspros* in *Siganus rivulatus*. Vrsta *Pampus argenteus* je bila šele pred kratkim potrjena kot lesepska selivka, čeprav je bila ujeta v vodah blizu Reke že davnega 1896. leta. Druge vrste so bile najdene v obdobju zadnjih dvajsetih let, večina med njimi pa v zadnjih nekaj letih. Vse vrste lesepskih rib so bile ujete posamič ali kvečjemu v dveh primerkih. Trenutno še nimamo nobenih podatkov o možnem vplivu lesepskih selivk na avtohtono ihtiofavno.

Upošteva devet novih vrst za Jadransko morje, šteje jadranska ribja favna 432 vrst, ki pripadajo 122 družinam. Pojavljanje lesepskih selivk v Jadranskem morju je bržkone treba pripisati istim dejavnikom, to je oceanografskim in klimatskim spremembam, zaradi katerih smo v zadnjih desetletjih v Jadranu zabeležili večje število termofilnih južnih vrst.

**Ključne besede:** ihtiofauna, selitev lesepskih vrst, vzhodni Jadran, Sredozemsko morje, Rdeče morje

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ON THE OCCURRENCE OF THE TRIPLETAIL, *LOBOTES SURINAMENSIS*  
(BLOCH, 1790) (OSTEICHTHYES: LOBOTIDAE), OFF THE COAST  
OF ALGERIA (SOUTHERN MEDITERRANEAN)

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ABSTRACT

*In the present paper, their authors report on a new record of the Tripletail, Lobotes surinamensis (Bloch, 1790), off the coast of Algeria (southern Mediterranean). A brief description of the specimen and comment on both occurrence and distribution of the species in the Mediterranean is given.*

**Key words:** teleost, Lobotidae, *Lobotes surinamensis*, distribution, Algeria, Mediterranean

TESTIMONIANZA DI PESCE FOGLIA, *LOBOTES SURINAMENSIS* (BLOCH, 1790)  
(OSTEITTI: LOBOTIDAE) AL LARGO DELLA COSTA DELL'ALGERIA  
(MEDITERRANEO MERIDIONALE)

SINTESI

*Gli autori riportano una nuova testimonianza di pesce foglia, Lobotes surinamensis (Bloch, 1790), al largo della costa algerina (Mediterraneo meridionale). L'articolo fornisce una breve descrizione dell'esemplare e commenta sia il ritrovamento che la distribuzione della specie in Mediterraneo.*

**Parole chiave:** Teleostei, Lobotidae, *Lobotes surinamensis*, distribuzione, Algeria, Mediterraneo



INTRODUCTION

The Tripletail *Lobotes surinamensis* (Bloch, 1790) is a cosmopolitan species found in all warm seas. The first written record of this teleost fish, as far as the Mediterranean is concerned, comes from Sicilian waters (Doderlein, 1875). Its presence in the Mediterranean has been since then noted by several authors, Ben-Tuvia (1953) and Golani (1996, 1997) in Israeli waters, Bini (1968) off Calabria, Italy and Tortonese (1975) off Rhodes, Greece, Turkey and Lebanon. Although *L. surinamensis* occurs in many places, it is still considered a rather rare species. Despite its wide distribution, it was not mentioned in the comprehensive studies by Dieuzeide (1953) carried out in coastal waters of Algeria. The first record from Tunisian coastal waters was made by Bradai (2000). An unsubstantiated record of this species was presented by Mr. Ali Messaoudi with a specimen of *L. surinamensis* presumably caught off Algiers (Anonymous, 1993). A recent survey conducted at some fishery sites along the Algerian coast revealed another specimen of this species.

MATERIAL AND METHODS

On 15 December 2002, a Tripletail was observed at the fish market of Algiers; it was caught by pelagic gill-net at a depth between 10 and 15 metres, off Annaba, city located in eastern Algeria, 90 km west to the Tunisian border (Fig. 1). The specimen was a female, 450-mm total length and weighing 4500 g. As the fishermen sold it immediately, we were unfortunately unable to preserve and include it in the Ichthyological Collection of the Algiers University.

RESULTS AND DISCUSSION

Morphometric measurements and meristic characteristics of this specimen are given in Table 1.

Body compressed, deep oval-shaped. Upper profile of head concave. Mouth oblique with protractible upper jaw. Jaws have bands of villiform teeth with rows of conical teeth on the outer edge. Preoperculum margin sharply serrated. Pelvic fin larger than pectoral. Posterior portions of the dorsal and anal rays rounded and opposite each other; together with the rounded caudal fin, they form a three-lobed caudal fin. Posterior part of dorsal and anal fins scaled. Colour brownish with differently shaped faded blotches and spots. Posterior margin of caudal fin yellow.

According to the authors, the Tripletail *L. surinamensis* lives solitary or in pairs. It feeds mainly on invertebrates and fish. This species is known for its strange behaviour: it floats motionless on its side on the surface of the water, for reasons still unknown. Schmid & Randall (1997) noted this behaviour pattern serves the fish

to camouflage against its predators and while placing itself in a good position to surreptitiously drawing closer to its prey. This probably explains why captures of this fish are rarely mentioned.

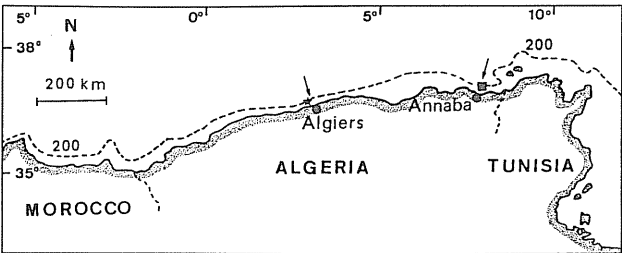


Fig. 1: Map of the Maghrebine shore showing the Algerian capture sites of *Lobotes surinamensis* (arrow pointing at the black star: first record; arrow pointing at the black square: second record).

Sl. 1: Zemljevid magrebske obale z oznakami lokacij v alžirskih vodah, kjer je bila ujeta vrsta *Lobotes surinamensis* (črna zvezdica: prvi zapis; črni kvadratik: drugi zapis).

Tab. 1: Morphometric measurements (in mm) and meristic counts of the specimen of *Lobotes surinamensis*.

Tab. 1: Morfometrični (v mm) in meristični podatki o primerku vrste *Lobotes surinamensis*.

Total length	450
Fork length	370
Space between tip of snout to caudal fin origin	361
Head length	60
Interorbital space	24
Space between tip of snout to pectoral fin origin	66
Space between tip of snout to dorsal fin origin	73
Space between tip of snout to pelvic fin origin	64
Space between tip of snout to anal fin origin	280
Space between snout and vent	310
Dorsal fin length	300
Pectoral fin length	70
Pelvic fin length	95
Anal fin length	90
Caudal fin length	45
Caudal fin width	43
Eviscerated mass in grammes	4500
Pelvic fin rays	I + 5
Dorsal fin rays	XII + 16
Anal fin rays	III + 15
Pectoral fin rays	12
Caudal fin rays	18
Ctenoid scales on tail	10

Fischer *et al.* (1981) reported the species along the eastern tropical Atlantic shore from the Strait of Gibraltar to the Gulf of Guinea. However, they noted that the species was captured only occasionally and that it seemed not to be very abundant in the area in spite of its commercial value, as its flesh is appreciated by local consumers. The species was reported off Guinea-Bissau (Sanchès, 1991), but not off Senegal (Cadenat, 1951; Séret & Opic, 1990; N'Dao, 1997; Diatta *et al.*, 2002). The information recently provided by fishermen, however, suggests its possible occurrence off the Cape Verde Peninsula. Moreover, *L. surinamensis* has not been reported from waters off Mauritania (Maigret & Ly, 1984).

Consequently, a progressive Mediterranean invasion by this species from the eastern Atlantic, as was the case with other fish species (Massuti & Stefanescu, 1993; Pizzicori *et al.*, 2000; Quignard & Tomasini, 2000; Hemida *et al.*, 2002), remains speculative.

In the Mediterranean, Tortonese (1975) noted that the Tripletail was occasionally captured off Sicily (Doderlein, 1875) and Calabria (Bini, 1968). He added that the species was also recorded off Rhodes, Greece, Turkey and Lebanon.

Roux (1986) reported the occurrence of *L. surinamensis* "in the Mediterranean and off Madeira and the Azores" and "elsewhere in all warm seas", but did not refer to any abundance of the species in these areas. Golani (1996, 1997) reported the species from the waters off Israel, and Bradaï (2000) from Tunisian waters.

It is possible that the recent finding of *L. surinamensis* in this area of the southern Mediterranean is due to an increase in the population and possible climatic changes, which led to other changes in intra-Mediterranean fish species distribution (Francour *et al.*, 1994; Quignard & Tomasini, 2000).

Moreover, Quignard & Tomasini (2000) noted: "The discovery of a large number of other species outside their usual area of distribution may be due to an increase of traditional prospection, or to the use of newer techniques..., which allow the exploration of otherwise inaccessible habitat", in agreement with Golani (1996) and Golani & Sonin (1996). This is probably the case of *L. surinamensis* from the Algerian coast, where the information given by fishermen showed that Tripletails are not uncommon in local waters. Captures of specimens are apparently observed throughout the year. A sustainable Tripletail population could be established off the Algerian coast, but identification is needed in order to confirm this opinion.

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## O POJAVLJANJU VRSTE *LOBOTES SURINAMENSIS* (BLOCH, 1790) (OSTEICHTHYES: LOBOTIDAE) V ALŽIRSKIH VODAH (JUŽNO SREDOZEMLJE)

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#### POVZETEK

Avtorji članka nas seznanjajo z novim podatki o pojavljanju vrste *Lobotes surinamensis* (Bloch, 1790) iz obrežnih alžirskih voda (južno Sredozemlje). V članku opisujejo to sicer redko ribjo vrsto in razpravljajo tako o njenem pojavljanju kot razširjenosti v Sredozemskem morju.

**Ključne besede:** teleost, Lobotidae, *Lobotes surinamensis*, razširjenost, Alžirija, Sredozemlje



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## NEW ADDITIONAL RECORDS OF IMPERIAL BLACKFISH, *SCHEDOPHILUS OVALIS* (CUVIER, 1833), WHITE TREVALLY, *PSEUDOCARANX DENTEX* (BLOCH & SCHNEIDER, 1801), AND ATLANTIC POMFRET, *BRAMA BRAMA* (BONNATERRE, 1788), IN THE EASTERN ADRIATIC

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### ABSTRACT

*The imperial blackfish, Schedophilus ovalis, white trevally, Pseudocaranx dentex, and Atlantic pomfret, Brama brama, specimens were caught in the eastern Adriatic. The main morphometric and meristic data are given. In spite of a number of scientific records regarding these species, we could still treat the imperial blackfish and white trevally as very rare species, and the Atlantic pomfret as a rare species in the Eastern Adriatic.*

**Key words:** imperial blackfish, white trevally, Atlantic pomfret, additional records, Eastern Adriatic

## NUOVE TESTIMONIANZE AGGIUNTIVE DI CONTROFOLO VIOLA, *SCHEDOPHILUS OVALIS* (CUVIER, 1833), CARANGO DENTICE, *PSEUDOCARANX DENTEX* (BLOCH & SCHNEIDER, 1801) E PESCE CASTAGNA, *BRAMA BRAMA* (BONNATERRE, 1788), IN ADRIATICO ORIENTALE

### SINTESI

*Esemplari di controfolo viola, Schedophilus ovalis, carango dentice, Pseudocaranx dentex, e pesce castagna, Brama brama, sono stati catturati in Adriatico orientale. L'articolo riporta i più importanti dati morfometrici e meristici. Conformemente a un numero di dati scientifici gli autori continuano a considerare controfolo viola e carango dentice specie molto rare, mentre il pesce castagna risulta essere una specie rara nell'Adriatico orientale.*

**Parole chiave:** controfolo viola, carango dentice, pesce castagna, testimonianze aggiuntive, Adriatico orientale



## INTRODUCTION

The imperial blackfish, *Schedophilus ovalis* (Cuvier, 1833), is a marine and benthopelagic species living in the Eastern Atlantic from Spain and throughout most of the Mediterranean southward, while in the Western Central Atlantic some small specimens have been recorded off Bermuda (Haedrich, 1986a; Jardas, 1996). It could also be found in Australia (Haedrich, 1990). This species is rare in the Adriatic Sea (Jardas, 1985, 1996).

The white trevally, *Pseudocaranx dentex* (Bloch & Schneider, 1801), is a reef-associated, marine and brackish species living at depths ranging from 80 to 200 m (Smith-Vaniz, 1986; Jardas, 1996). It lives in the Western Atlantic (from Bermuda, North Carolina and south to southern Brazil), in the Eastern Atlantic (Azores, Madeira, Canaries, Cape Verde, Ascension and Saint Helena Island), in the Mediterranean, in the Indo-Pacific (South Africa, Japan, Hawaii, Australia, Lord Howe and Norfolk Islands), in New Zealand, and in New Caledonia (Smith-Vaniz, 1986; Jardas, 1996). This species is very rare in the Adriatic Sea (Jardas, 1985, 1996).

The Atlantic pomfret, *Brama brama* (Bonnaterre, 1788), is a bathy- and epipelagic species occurring at depths ranging from 0 to 1,000 m. This oceanic and highly migratory species lives in the South Pacific, Indian Ocean, Western Atlantic (from Nova Scotia, Canada and Bermuda to Belize and the Antilles), and in the Eastern Atlantic (from central Norway southward to Algoa Bay and South Africa) (Haedrich, 1986b; Jardas, 1996). It could also be found in Australia (May and Maxwell, 1986), New Zealand (Paulin *et al.*, 1989) and Chile (Frimodt, 1995). This species is fairly rare in the Adriatic Sea (Jardas, 1985, 1996).

The data on biology and ecology of the above mentioned species in the Adriatic are very scarce. The aim of this paper is to provide first data on the morphometric and meristic characteristics of these species for the Adriatic Sea, some preliminary data on food items and data on their additional occurrence in the Eastern Adriatic.

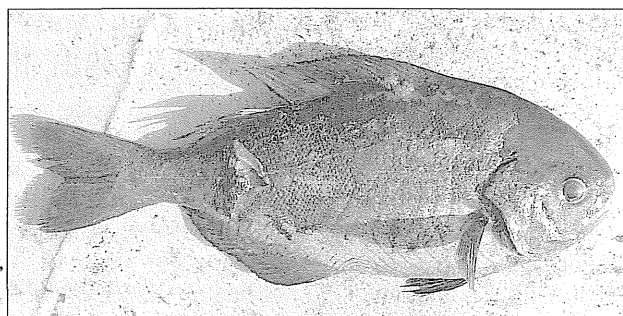
## MATERIAL AND METHODS

A specimen of the imperial blackfish (Fig. 1) was caught on 28 July 2003 with "brankarela" (ripping hook mounted together on the iron or wooden stick) in the open waters of Southern Adriatic, 35 Nm SE from Dubrovnik (Southern Adriatic), at about 1,000 m depth (Fig. 4: location A). A specimen of the Atlantic pomfret (Fig. 2) was caught on 30 August 2002 with bottom trawl in the Pomo Pit, at about 150 m depth (Fig. 4: location C). A specimen of the white trevally (Fig. 3) was caught on 30 October 2001 with trammel bottom set in Gvozdenac Cove (Vis Island) at 20 m depth (Fig. 4: location B).

The specimens were identified according to Jardas (1996). They are deposited (in jars with formaldehyde)

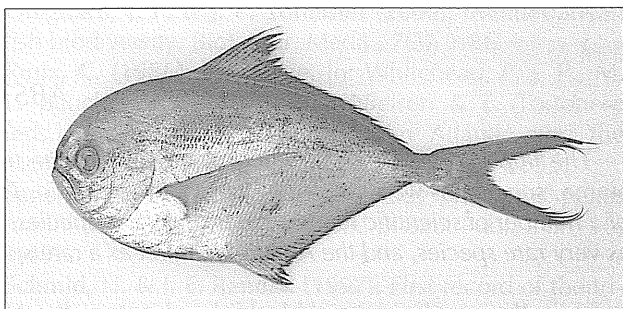
in the Ichthyological Collection of the Institute of Oceanography and Fisheries in Split, Croatia.

The specimens were preserved in 4% buffered formaldehyde, subsequently measured to the nearest 0.1 mm, and weighed to the nearest 0.1 g. Meristic characteristics considered were dorsal, anal, pectoral, ventral, caudal fins, and number of scales in the longitudinal line. Immediately after capture, fish were dissected and



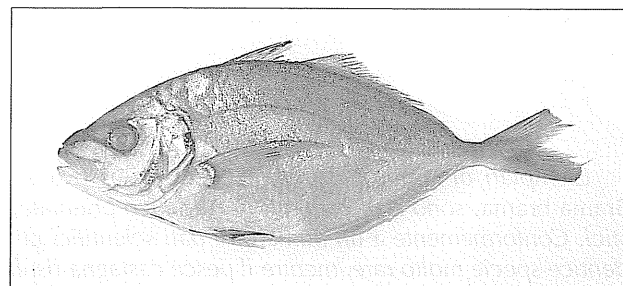
**Fig. 1:** *Schedophilus ovalis* caught in the Southern Adriatic. (Photo: V. Onofri)

**Sl. 1:** *Schedophilus ovalis*, ujet v južnem Jadranskem morju. (Foto: V. Onofri)



**Fig. 2:** *Brama brama* caught in Pomo Pit. (Photo: A. Pallaoro)

**Sl. 2:** *Brama brama*, ujeta v kotanji Pomo. (Foto: A. Pallaoro)



**Fig. 3:** *Pseudocaranx dentex* caught near Island Vis. (Photo: A. Pallaoro)

**Sl. 3:** *Pseudocaranx dentex*, ujet v bližini Visa. (Foto: A. Pallaoro)

the gut removed and preserved in 4% formalin solution to prevent food digestion. In the laboratory, identification of prey was carried out to the species level whenever possible.

RESULTS AND DISCUSSION

In Table 1, the main morphometric and meristic data of the three mentioned species are presented.

The specimen of the imperial blackfish was caught in the open waters of Southern Adriatic, at about 1,000 m depth (T=25 °C). This species prefers deep water at the edge of continental shelves and around oceanic islands; larger specimens dwell near the bottom (Jardas, 1996). According to literature, this record is the fourth so far of this species in the Adriatic Sea. In the Adriatic, *S. ovalis* was recorded for the first time by Kolombatović (1902) who named it *Centrophilus corcyrensis*, as it was

caught in the vicinity of Korčula Island (Southern Adriatic). The second specimen (without measures) of this species was captured together with *S. medusophagus* in the Pelješac Channel (Southern Adriatic) in 1982 (at a depth of 2 m, T=25 °C) where *Pelagia noctiluca* were also present (Onofri, 1986). On 26 June 1979, a single specimen (third record) of the imperial blackfish was caught with deep bottom trawl in the open waters of Southern Adriatic, about 20 Nm SE from Dubrovnik at a depth of about 1,000 m. Total length of the caught specimen was TL = 25.2 cm (no data on its weight and sex) (D. Viličić, pers. comm.). We assume that these periodical occurrences could be explained by the Adriatic ingressions, NAOi (North Atlantic Oscillation Index) and warming of Adriatic waters (Dulčić et al., 1999). Observations on the Adriatic ichthyofauna (period 1973-1998) showed changes in the quantitative and qualitative composition of the fish fauna. The number of thermo-

Tab. 1: Morphometric (in mm) and meristic data of the imperial blackfish, white trevally and Atlantic pomfret in the Eastern Adriatic.

Tab. 1: Morfometrični (v mm) in meristični podatki o vrstah *Schedophilus ovalis*, *Pseudocaranx dentex* in *Brama brama*, ujetih v vzhodnem Jadranskem morju.

Species	<i>Schedophilus ovalis</i>	<i>Pseudocaranx dentex</i>	<i>Brama brama</i>
Weight (g)	820.8	142.3	644.2
Morphometric characters (mm)			
Total length (TL)	387.5	226.7	406.2
Standard length (SL)	311.8	193.4	308.6
Head length (C)	83.8	59.4	79.2
Predorsal length (LPD)	69.3	68.5	95.8
First dorsal fin length (LD1)	191.2	24.2	153.4
Second dorsal fin length (LD2)	-	72.1	-
Preanal length (LPA)	168.4	113.8	145.3
Anal fin length (LA)	80.8	53.9	105.7
Prepectoral length (LPP)	77.7	57.3	84.1
Pectoral fin length (LP)	72.1	56.5	110.3
Preventral length (LPV)	84.1	55.9	102.7
Ventral fin length (LV)	55.2	26.9	29.4
Caudal fin length (LC)	98.2	48.2	136.2
Eye diameter (O)	18.6	13.3	19.2
Interorbital length (IO)	37.2	15.6	25.2
Preorbital length (PO)	14.0	24.1	19.9
Postorbital length (OLO)	51.2	21.9	40.1
Maximal body height (H <sub>max</sub> )	128.3	71.4	130.9
Minimal body height (H <sub>min</sub> )	32.8	8.6	20.2
First dorsal fin (D1)	VII / 30	VIII	III / 33
Second dorsal fin (D2)	-	I / 25	-
Anal fin (A)	III / 22	II + I / 21	II / 28
Pectoral fin (P)	21	I / 20	20
Ventral fins (V)	I / 5	I / 5	I / 5
Caudal fin (C)	4 + 16 + 4	9 + 8 + 9	5 + 17 + 5
Linea lateralis (LI)	95	28	83

philic species has increased; several species, scarce or rare until now, are more abundant, while others are new records (Dulčić *et al.*, 1999). The authors (*ibid.*) believe that the occurrence of the imperial blackfish and Cornish blackfish *S. medusophagus* in the Adriatic waters is the result of water warming. The northward extension of *S. ovalis* to the Bay of Biscay (Quero *et al.*, 2000) and recent occurrences of young *S. ovalis* along the French Mediterranean coasts (Francour & Javel, 2003) could support this hypothesis. Francour & Javel (2003) assume that the observations of small to medium sized *S. ovalis* they made in 2000-2001 in the Alpes-maritimes department (Cannes, Antibes, Beaulieu/Mer) could be also explained by the present water warming (Francour *et al.*, 1994). According to Orsi-Relini *et al.* (1990), the size of the imperial blackfish specimen of about 45 cm TL corresponds to the first year of its life, and taking this into consideration, the caught specimen from our study is a juvenile (0+). The results of Deudero *et al.* (1999) confirm the rare observations of the imperial blackfish made by Relini *et al.* (1994) in the Ligurian Sea. Moreover, only 3 catches of this species have been reported from the Balearic Sea (Massutí & Stefanescu, 1994).

Several different groups of organisms were found in the stomach of the specimen: Narcomedusae (7 specimens of *Solmissus albescens*), Decapoda (12 pieces of legs and remains of carapax), Chaetognatha (1 specimen of *Sagitta* sp.), Tunicata (Appendicularia, 3 specimens of *Oikopleura longicauda*, some parts of *Pyrosoma* community), and fish scales (n=5). Maul (1964) found several indigested *Pyrosoma* sp. in the stomachs of the black imperial fish. Orsi-Relini *et al.* (1990) also found a lot of *Pyrosoma* sp., as well as 8 specimens of pteropod *Cymbulia peroni* (in one stomach) and euphausiidae shrimp *Meganyctiphanes norvegica* (in one stomach). Relini *et al.* (1994) discovered undigested pyrosomes and few fragments of jelly plankton in the stomachs of young black imperial fish.

The meristic and morphometric data on the imperial blackfish presented in Table 1 are the first for this species from the Adriatic Sea and are in agreement with the data presented for the specimen from the Corvo Island (Azores) (www.fishbase.org) and with partially presented data by Haedrich (1986a).

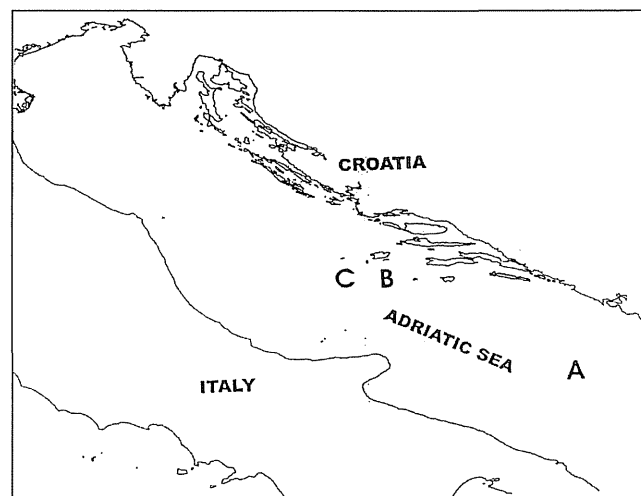
The specimen of white trevally caught during this study is the fourth of this species in the Eastern Adriatic. *P. dentex* was recorded for the first time in the Eastern Adriatic near Duba area (Pelješac Peninsula). This specimen was (TL=34.4 cm) caught on 11 July 1986 at 6 m depth with a net called "prostica" (Pallaoro & Jardas, 1996). Second specimen was caught with long line near Lastovo Island in 1986 (Milišić, 1994). Third specimen was captured in November 2001 near Vis Island (TL=35.8 cm) with trammel bottom set (Matić, *pers. comm.*).

The meristic and morphometric data for the white trevally presented in Table 1 are the first for this species

from the Adriatic Sea and are in agreement with the data presented for the specimen from Branco Islet (Cape Verde Islands) (www.fishbase.org) and the data presented by Smith-Vaniz (1986).

We found digested fish larvae and postlarvae and specimens of Mysidacea in the caught specimen's stomach (we were unable to determine any species, since the material was completely digested). This species feeds on plankton by ram-filtering and suction on bottom invertebrates (Smith-Vaniz, 1986). Russell (1983) reported that this species (Goat Island, northeastern coast of New Zealand) feeds on euphausiids (larvae), amphipods (juveniles and adults), copepods (juvenile and adults) and gastropods (juvenile and adults). Its diet is also composed of squid, cuttlefish, finfish, crabs, shrimps, sea stars, sea urchins and bivalves (www.fishbase.org).

Records of the Atlantic pomfret in the Adriatic are not as scarce as of the previous two species. It should be pointed that all records of this species were made in relatively shallow waters, in spite of the fact that this bathy- and epipelagic species could be found at depths of 1,000 m. It is highly migratory and occasionally comes close to shore. It is a seasonal migrant occurring in small schools and its movements are apparently temperature-related (Jardas, 1996). Three records for the Eastern Adriatic were reported in local newspapers (in 1980, 1981 and 1982 near the town of Rijeka), while one record was made by Pallaoro & Jardas (1996) in the Kaštela Bay-Split area on 7 February 1984 (TL=45.7 cm). One specimen is deposited in the Ichthyological Collection of the Natural History Museum in Rijeka (Croatia) without any data (Kovačić, 1998). Two larval stages



**Fig. 4: Map with the locations of records** (A – *Schedophilus ovalis*, B – *Pseudocaranx dentex*, C – *Brama brama*).

**Sl. 4: Zemljevid z lokacijami zabeleženih vrst** (A – *Schedophilus ovalis*, B – *Pseudocaranx dentex*, C – *Brama brama*).



were recorded for the first time in the River Neretva Estuary at a depth of 22 m (TL=4.36 mm and TL=5.00 mm) (Dulčić, 1999).

The meristic and morphometric data for the Atlantic pomfret presented in Table 1 are the first for this species from the Eastern Adriatic and are in agreement with the data presented by Haedrich (1986b), while they slightly differ from those regarding the specimen from Boavista Island (Cape Verde Islands) (www.fishbase.org).

We found only two specimens of *Argentina sphyraena* fish in the stomach of the caught Atlantic pomfret from Pomo Pit. Haedrich (1986b) described the Atlantic pomfret as an opportunistic feeder on small fishes, cephalopods, amphipods and euphausiids.

According to Morović (1973), the rarity of certain fish species could be evaluated from the records in scientific literature. Same author have pointed that if the species is recorded less than five times, it should be

treated as a very rare species. According to this suggestion we could treat the imperial blackfish and white trevally (4 records in scientific literature until now) as very rare species in the Eastern Adriatic, and the Atlantic pomfret as a rare species. We must also be careful with tools (gears) for providing target species if wishing to evaluate their rarity, as it is hard to sample the imperial blackfish (during different life phases) using conventional methods. FADs (Fishing Attractive Devices) provide a useful tool for studying the mentioned species (Deudero et al., 1999), so it could be proposed for next studies on fish assemblages in the Adriatic.

The status of investigated species needs to be evaluated on a continuous basis, as it is becoming increasingly apparent that uncommon species, and particularly those on the edge of their distribution, can be essential indicators of environmental change (Swabby & Potts, 1990).

## NOVI PODATKI O VRSTAH *SCHEDOPHILUS OVALIS* (CUVIER, 1833), *PSEUDOCARANX DENTEX* (BLOCH & SCHNEIDER, 1801) IN *BRAMA BRAMA* (BONNATERRE, 1788), UJETIH V VZHODNEM JADRANSKEM MORJU

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### POVZETEK

V vzhodnem Jadranu so bile v zadnjih dveh letih ujete vrste *Schedophilus ovalis*, *Pseudocaranx dentex* in *Brama brama*, v tem morju sicer neobičajne ribe. V članku so podani morfometrični in meristični podatki vseh treh vrst. Kljub dejstvu, da o njih obstaja vrsta znanstvenih zapisov, smemo reči, da sta *Schedophilus ovalis* in *Pseudocaranx dentex* zelo redki, *Brama brama* pa redka vrsta v vzhodnem Jadranu.

**Ključne besede:** *Schedophilus ovalis*, *Pseudocaranx dentex*, *Brama brama*, novi podatki, vzhodni Jadran

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**SREDOZEMSKI MORSKI PSI**

**SQUALI MEDITERRANEI**

**MEDITERRANEAN SHARKS**





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## RECORDS OF THE BLUNTNOSE SIX-GILL SHARK, *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE) IN THE MEDITERRANEAN SEA: A HISTORICAL SURVEY

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### ABSTRACT

*Captures of the bluntnose sixgill shark Hexanchus griseus, based on a literature review and on original data collected from different areas, especially off the coasts of France, Spain, Italy, Malta and Tunisia, offered an opportunity to enlarge and improve upon current knowledge about some aspects of its distribution in the Mediterranean Sea. At present time, the relative abundance of H. griseus in this sea and particularly along the Algerian coast could be partly explained by migrations from the eastern Atlantic through the Strait of Gibraltar into the Mediterranean Sea. Furthermore, it appears that H. griseus probably lives and reproduces off the Maghrebine shore.*

**Key words:** Chondrichthyes, Hexanchidae, *Hexanchus griseus*, distribution, Mediterranean Sea

## SEGNALAZIONI DI SQUALO CAPOPIATTO, *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE) IN MEDITERRANEO: REVISIONE STORICA

### SINTESI

*Catture di squalo capopiatto Hexanchus griseus, basate su dati di letteratura e dati originali provenienti da diverse aree, specialmente da acque al largo di Francia, Spagna, Italia, Malta e Tunisia, offrono l'opportunità per allargare e migliorare l'attuale conoscenza di alcuni aspetti della distribuzione di tale specie in Mediterraneo. Allo stato attuale, l'abbondanza relativa di H. griseus in questo mare e specialmente lungo le coste algerine può essere in parte spiegata grazie alle migrazioni dall'Atlantico orientale al Mediterraneo attraverso lo stretto di Gibilterra. Pare inoltre che H. griseus viva e si riproduca al largo della costa magrebina.*

**Parole chiave:** *Hexanchus griseus*, revisione storica, distribuzione, Mediterraneo

## INTRODUCTION

The bluntnose six-gill shark, *Hexanchus griseus*, is widely distributed in temperate and tropical waters and occurs in both eastern and western Atlantic, Pacific and Indian Oceans and in the Mediterranean Sea (Compagno, 1984). In this sea, the species is reported in ichthyological treatises (Cadenat & Blache, 1981; Boeseman, 1984; Fischer *et al.*, 1987; Moreno, 1995; Notarbartolo di Sciarra & Bianchi, 1998) or papers (Capapé, 1989; Quignard & Tomasini, 2000). It is also reported from restricted areas in the western Mediterranean basin, off Spain (Lozano Rey, 1928; Barrull & Mate, 1996a, b, 2002; Barrull *et al.*, 1999), France (Moreau, 1881; Capapé *et al.*, 2000), Italy (Arcidiacono, 1931; Tortonese, 1956; Bini, 1967; De Maddalena, 2001), Croatia (Šoljan, 1975), Greece (Economidis, 1973; Economidis & Bauchot, 1976), as well as the eastern basin, off Israel (Ben-Tuvia, 1971; Golani, 1996, 1997) and Lebanon (Mouneimne, 1977).

Off the Maghrebine shore, *H. griseus* was considered to be a rare species off both the Algerian (Dieuzeide *et al.*, 1953) and Tunisian coasts (Capapé, 1989; Bradaï, 2000). However, the research conducted at fishing sites located along the Algerian coast offered the opportunity to report herein abundant captures of *H. griseus*.

Mediterranean distribution of the bluntnose six-gill shark is dealt in this paper, based on a literature review and original data collected from different areas, especially off the coasts of France, Spain, Italy, Malta, Algeria and Tunisia.

## MATERIAL AND METHODS

Both literature and original records collected from different areas of the Mediterranean Sea are given (Tab. 1) and, whenever possible, sex, total length in millimetre following Compagno (1984), total weight in kg, method of capture, capture date, fishing site and/or area, the country and the reference with name(s) of author(s) in case of previous data.

With special regard to the Algerian coast (Tab. 1: records No. 113 and 114), investigations were conducted from 1996 to 2000. All the observed specimens were caught by longline at a depth between 30 and 700 m (Figs. 1, 2). Unfortunately, the fishermen eviscerated them when landed on the boat deck. The specimens were sexed.

The relationship total weight vs. total length was studied for both males and females concerning the specimens of other Mediterranean areas. The linear regression was expressed in decimal logarithmic coordinates. Correlations were assessed by least-squares regression.

## RESULTS

Off the Mediterranean coasts, to our knowledge, 114 records of *H. griseus* have been reported to date (Tab. 1). One hundred and one records were made in the western basin and 13 in the eastern one. Eleven countries were concerned by these records: Spain (41), Italy (25), France (18), Tunisia (11), Turkey (4), Algeria (2),

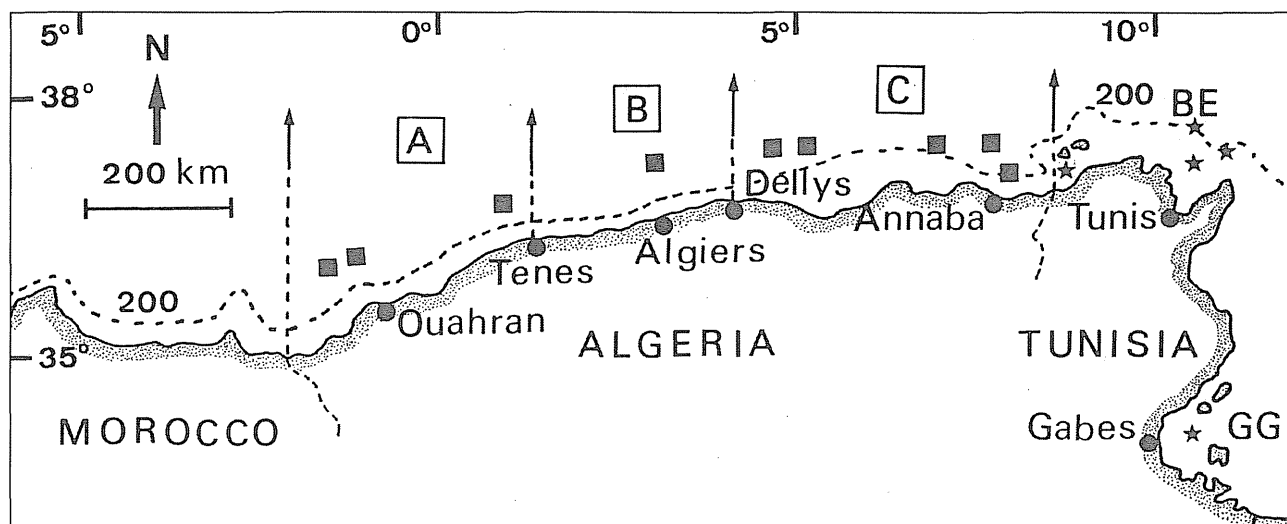


Fig. 1: Map of the Maghrebine shore, indicating the places where one or more captures were made off the Algerian (black squares) and Tunisian coasts (black stars). A: Eastern area; B: Central area; C: Western area; BE: Bank of Esquerquis; GG: Gulf of Gabes.

Sl. 1: Zemljevid magrebske obale z oznakami, kjer so v bližini alžirske (črni kvadrati) in tunizijske obale (črne zvezdice) ujeli enega ali več morskih psov šesteroškrjarjev. A: vzhodno območje; B: osrednje območje; C: zahodno območje; BE: Banc des Esquerquis; GG: Gabeški zaliv.



Monaco (2), Malta (2), Greece (2), Israel (2) and Croatia (5). Seventy-seven fishing sites were reported. In all, 202 specimens were sexed, 128 of which were females and 74 males. The sharks were captured by trawling (33), longlines (19), anglers (4), gill-nets (5), seining (1). Moreover, five specimens were beaching and six floating. Eight captures were made at depths less than 100 m, a single between 3.6 and 5.4 m, eight ranged from 100 to 200 m depth, and 16 from 500 m to 2000 m maximum. The smallest specimen (Tab. 1: No. 6), a female 556 mm TL, was caught off Marbella (Lozano Rey, 1928). The largest specimens were two males (Tab. 1: No. 86 and 87), both having 5 m TL and weighing 600 kg and 500 kg respectively. They were caught off the Island of Minorca and off Bosa, Sardinia. Among these records, the females were globally larger than the males.

Free-swimming specimens recorded off the Mediterranean coasts by Lozano Rey (1928), Capapé *et al.* (2000) and Barrull & Mate (2000) are included in Table 1 (No. 35 and 58). They exhibited an unhealed scar on the ventral surface and a residual internal vitelline vesicle. They suggested that birth occurred between 556 and 603 mm TL in the Mediterranean Sea.

The relationship total weight vs total length for both males and females from the Mediterranean coast (Fig. 3) is:  $\log TW = 3.137 \log TL - 8.6133$ ;  $r = 0.957$ ;  $n = 29$ .

The heaviest specimen was a male, 4000 mm TL, caught off Izmir, Turkey (Tab. 1: No. 57), weighing 1000 kg according to Mater *et al.* (2000). However, this weight suggests an overestimation because specimens of larger size, 5000 mm TL (Tab. 1: No. 88 and 89), did not exceed 600 kg.



**Fig. 2:** *Hexanchus griseus* male, 1300 mm total length, captured off central Algerian area and observed at the Algiers fish market. (Photo: F. Hemida)

**Sl. 2:** Samec morskega psa šesteroškrgarja *Hexanchus griseus*, celotna dolžina 1300 mm, ujet v vodah blizu osrednje alžirskega območja in opažen na alžirski ribji tržnici. (Foto: F. Hemida).

In Tunisian waters, the female caught at the level of Bank of Esquerquis (Tab. 1: No. 38) was 4650 mm TL and contained 57 ripe oocytes in the ovaries; the female caught in the Gulf of Gabès (Tab. 1: No. 63) was 3940 mm TL and contained 100 ripe oocytes.

The two females from Tunisian waters were caught in April and probably at the time of ovulation. The neonates were captured off Sete, southern France, and off Catalonia, northern Spain, between November and April.

## DISCUSSION

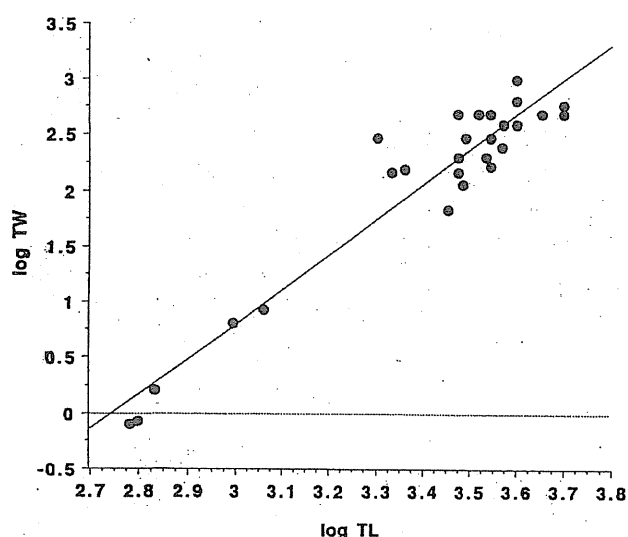
Records of bluntnose six-gill sharks were more numerous in the western Mediterranean basin than in its eastern part. This suggests that in the latter area, the species was less abundant and/or the waters were less exploited and/or information reported to a lesser extent.

Formerly, the species had been abundant in the northern Mediterranean, especially along the French coast, where a decline of these populations has actually been observed off Sète (Capapé *et al.*, 2000) and off the marine area of Nice. Information provided by fishermen showed that the species was rarely caught in the latter area in recent times, and specific six-gill shark fishing was cancelled. However, the species continued to be regularly and commonly caught off the coast of Croatia (Jardas, *pers. comm.*), off Italy (Barrull & Mate, 2000; Tab. 1) and off Spain (Barrull & Mate, 1996, 2000; Tab. 1).

By contrast, the bluntnose sixgill shark had been considered a rare species off the Algerian coast (Dieuzeide *et al.*, 1953), but this opinion has not been corroborated to date. At present, the relative abundance of the species in Algerian waters is probably due to the development of fishery activities in the area and the research conducted since 1996 on Algerian elasmobranch species (Hemida, 1998; Hemida & Labidi, 2001; Hemida & Capapé, 2002). This phenomenon could not be conjunctural and fortuitous. Captures were significantly more abundant in both western and eastern areas than in the central area (Fig. 1). Furthermore, *H. griseus* is commonly caught off Annaba, city located 100 km from the Tunisian border, according to information provided by fishermen. The captures extended in the Tunisian adjacent waters suggest that off the Maghrebine shore, a consequent *H. griseus* population could live and reproduce.

*H. griseus* lived in deep sea waters generally from 50 to 2000 m and approached the coast; some captures were made at lower depths between 50 and 100 m (Tab. 1).

Along the Maghrebine shore, *H. griseus* specimens were caught on sandy, muddy, but also detritic and rocky bottoms. This explained why the species were commonly caught by trawlers and longlines in both Algerian and Tunisian waters.



**Fig. 3: Relationships total weight (TW) vs. total length (TL) expressed in logarithmic co-ordinates for both females and males from Mediterranean areas.**

**Sl. 3: Razmerje med celotno težo (TW) in celotno dolžino (TL), izraženo v logaritmičnih koordinatah tako za samice kot za samce morskih psov šesteroškrjarjev iz sredozemskih voda.**

The *H. griseus* specimens reported in Table 1 were particularly from France, Spain, Croatia, Italy, Algeria and Tunisia. However, misidentifications with its closely related species, the bigeyed sixgill shark *H. nakamurai*, cannot be excluded even though they remain questionable. Compagno (1984) wrote that *H. nakamurai* is "widely but spottily distributed in warm temperate and tropical seas" and reported the species "off Gibraltar". The presumable occurrence of *H. nakamurai* in the Mediterranean Sea was based on a stuffed specimen deposited in the Museum of Natural History of Florence (Italy) and referenced 6028. It was a male measuring 980 mm TL (Tortonese, 1985; Vanni, 1992). Barrull & Mate (2002) gave a photograph of the specimen (*H. vitulus*; p. 262) and wrote that it was previously acquired by the Museum of Natural History of Florence from a high school, "Istituto Superiore Femminile", located in Florence. Barrull & Mate (2002) stated that the Mediterranean origin of this specimen remained doubtful. However, Barrull & Mate (2002) reported that a *H. nakamurai* was caught by longline off the Greek coast in 2001. It was a male measuring 1000 mm and weighed approximately 3 kg. At present time, this single record does not allow to state that a *H. nakamurai* population permanently lives and reproduces in the Mediterranean Sea. It could be considered only an occasional visitor to the Mediterranean Sea, as was the case of other elasmobranch species (Pastore & Tortonese, 1986; Hemida et al., 2002).

branch species (Pastore & Tortonese, 1986; Hemida et al., 2002).

In the Bay of Biscaye, Vaillant (1901) reported that TL ranged from 680 to 736 mm for near term embryos in a gravid female, Desbrosses (1938) recorded a free swimming specimen and two near term embryos having 720 mm and 670 mm TL respectively. Off California, Ebert (1986) wrote that near-term embryos TL ranged from 680 to 736 mm. Size at birth showed a large range, whatever the area. However, Bigelow & Schroeder (1948) reported free swimming specimens from 429 to 720 mm TL, but they probably collected both *H. griseus* and *H. nakamurai*, since the illustration they supplied concerned a bigeyed sixgill shark. Moreover, size at birth occurred at about 430 mm TL in *H. nakamurai* according to Compagno (1984).

A literature review shows that *H. griseus* could reproduce once per year (Risso, 1810; Canestrini, 1861 [in Tortonese, 1956]) or twice per year (Ninni, 1912). The two females from Tunisian waters were caught in April and were probably in the time of ovulation. The neonates were captured off Sete (southern France) and off Catalonia (northern Spain) between November and April. According to Desbrosses (1938), females expelled foetuses between October and May.

The records reported from the Algerian coast and the Mediterranean records summarized in Table 1 reveal a non negligible density population of *H. griseus*. A decrease of stocks seems most probably due to fishing pressures. The species was not recorded in the Red Sea (Gohar & Mazhar, 1964; Compagno, 1984; Golani, 1997), but was reported from the eastern Atlantic, both north and south from the Strait of Gibraltar. Moreover, it is considered to be relatively common in the eastern tropical Atlantic (Fischer et al., 1981). *H. griseus*, which migrated from Atlantic areas and entered the Mediterranean Sea through the Strait of Gibraltar, could be a hypothesis to partially explain the present abundance of *H. griseus* off the Algerian coast and in other Mediterranean areas as it was probably the case of other shark species recorded in the same area (Hemida et al., 2002).

#### ACKNOWLEDGEMENTS

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**Tab. 1: Historical records of *Hexanchus griseus* in the Mediterranean sea (M - male, F - female).****Tab. 1: Zgodovinski podatki o pojavljanju morskega psa šesteroškrjarja *Hexanchus griseus* v Sredozemskem morju (M - samec, F - samica).**

No.	N	Sex	TL (mm)	Weight (kg)	Depth (m)	Capture method	Fishing site	Country	Fishing date	Reference
1	1	F	?	?	?	?	Rimini- Ravenna	Italy	15/03/1876	Vanni (1992)
2	1	F	?	?	?	Longline	Naples	Italy	16/02/1886	Carruccio (1896)
3	1	F	?	?	?	?	Nice	France	02/01/1903	Vanni (1992)
4	1	F	?	?	?	?	Island of Elba	Italy	08/02/1911	Vanni (1992)
5	1	?	2970	?	1000	Longline	Monaco	Monaco	02/01/1912	Roule (1912)
6	1	F	556	?	?	?	Marbella	Spain	before 1916	Lozano Rey (1928)
7	1	F	4000	?	?	?	Garraf	Spain	03/12/1932	Sagarra (1932)
8	1	?	±3500	?	?	?	Gulf of Kvarner	Croatia	1935	Barrull & Mate (2000)
9	3	?	?	?	?	Gill-net	Gulf of Aigues-Mortes	France	1941/1948	Granier (1964)
10	1	F	650	?	?	?	Nice	France	spring 1889	Bigelow & Schroeder (1948)
11	19	F	<1200	?	?	Trawling	Sète	France	1950-1955	Euzet (1960)
12	15	M	<1600	?	?	Trawling	Sète	France	1950-1955	Euzet (1960)
13	1	M	2430	86	200	Longline	Southern Adriatic	Croatia	before 1955	Kirinčić & Lepetić (1955)
14	1	M	?	135	500	Longline	Southern Adriatic	Croatia	before 1955	Kirinčić & Lepetić (1955)
15	1	M	?	150	600	Longline	Southern Adriatic	Croatia	before 1955	Kirinčić & Lepetić (1955)
16	1	F	3800	290	700	Longline	Southern Adriatic	Croatia	before 1955	Kirinčić & Lepetić (1955)
17	1	F	2920	135	?	?	Nice	France	before 1956	Tortonese (1956)
18	1	F	1140	8.6	30	Trawling	Agde	France	04/04/1961	Quignard <i>et al.</i> (1962)
19	1	?	?	?	?	?	Caprera (Sardinia)	Italy	1960	Giudici & Fino (1989)
20	1	M	2550	?	500	Trawling	Port-Vendres	France	02/04/1965	Laubier <i>et al.</i> (1966)
21	1	M	4150	?	58	Trawling	Palavas-les-Flots	France	01/04/1966	Laubier <i>et al.</i> (1966)
22	1	M	±2800	?	?	?	Canet de Mar	Spain	sixties end	Mas (1997)
23	>3	?	<2110	?	?	?	Coast of Israel	Israel	1971	Ben-Tuvia (1971)
24	>3	?	3300	?	750	?	Coast of Israel	Israel	1971	Gilat & Gelman (1984)
25	?	?	?	?	80-130	?	Gulf of Gabes	Tunisia	1971	Ktari-Chakroun & Azouz (1971)
26	3	?	?	?	450-700	Trawling	Blanes	Spain	1972-1974	Matallanas (1979)
27	1	?	1170	?	?	?	Gulf of Thermaïkos	Greece	22/04/1974	Economidis & Bauchot (1976)
28	1	F	3000	?	?	?	La Seyne-sur-Mer	France	08/1976	Capapé (1977)
29	1	M	2650	?	?	?	La Seyne-sur-Mer	France	08/1976	Capapé (1977)
30	1	F	>3000	?	60	Gill-net	Gulf of Gabes	Tunisia	05/04/1977	Unpubl. data
31	1	M	1090	?	60	Gill-net	Gulf of Gabes	Tunisia	06/1978	Unpubl. data
32	1	?	?	?	501	?	Dènia-Island of Eivissa	Spain	before 1981	Matallanas <i>et al.</i> (1981)



33	1	?	?	?	418	?	Island of Mallorca	Spain	before 1981	Matallanas <i>et al.</i> (1981)
34	1	?	3050	177	?	Longline	Cape of Begur	Spain	1977-1980	Barrull & Mate (2000)
35	1	F	560	?	365	Trawling	Barcelona	Spain	15/11/1982	Barrull & Mate (2000)
36	1	F	970	?	<50	Trawling	Sitges	Spain	01/07/1983	Barrull & Mate (2000)
37	?	?	?	?	100-700	?	Vilanova i la Geltrù – Sitges	Spain	before 1984	Del Cerro & Portas (1984)
38	1	F	4650	?	>400	Trawling	Bank of Esquerquis	Tunisia	03/1986	Unpubl. data
39	1	?	4150	?	?	Trawling	Fuengirola	Spain	spring 1986	Pinto (1994)
40	25y <sup>-1</sup>	?	?	±200	<1200	Longline	Nice	France	summer	Delattre & Maigret (1986)
41	3	?	<5000	?	<1500	Longline	Off Corsica	France	1986	Miniconi (1987)
42	1	M	3000	?	?	Gill-net	Gulf of Gabes	Tunisia	08/06/1987	Unpubl. data
43	1	M	3300	?	?	Trawling	Gulf of Tunis	Tunisia	19/08/1987	Unpubl. data
44	1	M	2800	?	600	Longline	Off Tabarka	Tunisia	20/07/1988	Unpubl. data
45	1	F	625	0.86	50	Trawling	Sète	France	01/1989	Capapé <i>et al.</i> (2000)
46	1	?	±1700	?	?	?	Balearic Isles	Spain	1990	Barrull & Mate (2000)
47	1	F	4100	?	?	?	Malta	Malta	02/1990	Barrull & Mate (2000)
48	1	F	4100	?	?	?	La Valette	Malta	04/1990	Barrull & Mate (2000)
49	1	F	3500	500	?	?	Off Istanbul	Turkey	19/12/1990	Mater <i>et al.</i> (2000)
50	1	M	4000	?	?	?	Blanes	Spain	27/12/1990	Barrull & Mate (2000)
51	1	M	±2500	?	?	?	Island of Mallorca	Spain	1989-1991	Barrull & Mate (2000)
52	1	?	2500	?	?	?	Ragusa	Italy	19/03/1991	Barrull & Mate (2000)
53	1	F	4000	?	?	Floating	Palamos	Spain	14/09/1991	Unpubl. data
54	1	F	3420	200	?	Beaching	Livorno	Italy	17/02/1992	Barrull & Mate (2000)
55	1	F	2000	?	?	Longline	Blanes	Spain	17/07/1992	Barrull & Mate (2000)
56	1	?	±3500	168	?	?	Çala Ratjada (Mallorca)	Spain	13/08/1992	Barrull & Mate (2000)
57	1	?	±4000	1000	< 2000	?	Izmir	Turkey	23/01/1993	Mater <i>et al.</i> (2000)
58	1	F	603	0.785	50	Trawling	Sète	France	04/1993	Capapé <i>et al.</i> (2000)
59	1	M	±3500	?	?	Trawling	Off Mao (Menorca)	Spain	19/06/1993	Unpubl. data
60	1	?	2150	150	?	Angler	Cosenza	Italy	17/08/1993	Barrull & Mate (2000)
61	1	M	2850	68.5	?	Trawling	Sant Carles de la Ràpita	Spain	19/04/1994	Barrull & Mate (2000)
62	1	M	2000	?	137	Longline	Gulf of Gabes	Tunisia	29/04/1994	Unpubl. data
63	1	F	3940	?	137	Longline	Gulf of Gabes	Tunisia	29/04/1994	Unpubl. data
64	1	F	3000	200	?	Floating	Cambrils	Spain	25/05/1994	Barrull & Mate (2000)
65	1	M	650	?	?	?	Llançà	Spain	20/08/1994	Barrull & Mate (2000)

66	1	M	680	?	?	?	Llança	Spain	17/03/1995	Barrull & Mate (2000)
67	1	F	2900	?	?	Floating	Sant Antoni de Calonge	Spain	25/08/1995	Barrull & Mate (2000)
68	1	F	2500	?	?	Beaching	Tarragona	Spain	24/09/1995	Barrull & Mate (2000)
69	1	F	1030	?	?	?	Llança	Spain	15/03/1996	Barrull & Mate (2000)
70	1	F	860	?	?	?	Llança	Spain	22/03/1996	Barrull & Mate (2000)
71	1	F	?	?	?	?	Tropea	Italy	05/05/1996	Barrull & Mate (2000)
72	1	M	844	?	?	?	Roses	Spain	29/11/1996	Barrull & Mate (2000)
73	1	M	2500	?	50	Seining	Sea of Marmara	Turkey	20/02/1997	Kabasakal (1998)
74	1	M	2800	±200	?	Beaching	Alberese	Italy	21/07/1997	Barrull & Mate (2000)
75	1	?	±2000	300	?	Longline	Amantea	Italy	summer 1997	Barrull & Mate (2000)
76	1	F	>3000	>500	?	Trawling	Port de Solller (Mallorca)	Spain	16/07/1998	Barrull & Mate (2000)
77	1	?	3500	?	?	?	Island of Formentera	Spain	08/1998	Barrull & Mate (2000)
78	1	F	?	?	?	Trawling	Sari-Solenzara (Corsica)	France	08/1998	Barrull & Mate (2000)
79	1	F	3000	?	?	Trawling	Porto Empedocle (Sicily)	Italy	10/08/1998	Barrull & Mate (2000)
80	1	M	2500	?	?	Trawling	Portopalo (Sicily)	Italy	18/08/1998	Barrull & Mate (2000)
81	1	M	2300	?	?	Trawling	Portopalo (Sicily)	Italy	18/08/1998	Barrull & Mate (2000)
82	1	?	3500	300	?	Gill-net	Cala Ratjada (Mallorca)	Spain	20/09/1998	Unpubl. data
83	1	F	1700	?	3.6-5.4	Longline	Blanes	Spain	10/11/1998	Barrull & Mate (2000)
84	1	M	2500	>170	<1000	Angler	Gulf of Mazarron	Spain	02(?) / 1999	Barrull & Mate (2000)
85	1	M	3500	500	?	Beaching	Island of Eivissa	Spain	12/03/1999	Barrull & Mate (2000)
86	1	?	±4000	?	?	?	Island of Favignana	Italy	03/06/1999	Barrull & Mate (2000)
87	1	F	3650	?	?	Floating	Ravallo	Italy	06/06/1999	De Maddalena (1999)
88	1	M	5000	600	?	Trawling	Island of Menorca	Spain	15/07/1999	Unpubl. data
89	1	M	5000	500	?	Floating	Bosa (Sardinia)	Italy	01/08/1999	Unpubl. data
90	1	?	4500	500	?	?	Naples	Italy	05/08/1999	Unpubl. data
91	1	?	2300	?	?	?	Izmir	Turkey	19/12/1999	Mater <i>et al.</i> (2000)
92	1	?	±1500	?	>200	Trawling	Sète	France	Winter 2000	Unpubl. data
93	1	M	2650	?	?	?	Palamos	Spain	02/2000	Unpubl. data
94	1	F	630	?	600-800	Trawling	Barcelona	Spain	10/02/2000	Unpubl. data
95	1	?	2500	160	?	Longline	Island of Tavolara	Italy	02/05/2000	Unpubl. data
96	1	?	3700	250	?	Trawling	Island of Elba	Italy	08/2000	Unpubl. data

97	1	?	3500	300	?	Angler	Gulf of Santa Eufemia	Italy	16/09/2000	Unpubl. data
98	2	?	?	50-90	?	Longline	Monaco	Monaco	2001	Unpubl. data
99	1	F	3110	<300	135-138	Trawling	Mataro	Spain	22/01/2001	Unpubl. data
100	1	F	992	5.50	528	Trawling	Barcelona	Spain	21/02/2001	Unpubl. data
101	1	?	4000	650	500	Trawling	Off southeast Sardinia	Italy	03/2001	Unpubl. data
102	1	F	676	1.64	528	Trawling	Barcelona	Spain	27/03/2001	Unpubl. data
103	1	?	?	500	?	Trawling	Off Ragusa (Sicily)	Italy	07/07/2001	Unpubl. data
104	1	F	4000	350	600-700	Angler	Catanzaro	Italy	06/08/2001	Unpubl. data
105	1	?	4000	400	?	Floating	Eivissa (Balearic Isles)	Spain	21/08/2001	Unpubl. data
106	2	?	<3000	±150	?	Trawling	Gulf of Aranci (Sardinia)	Italy	12/09/2001	Unpubl. data
107	1	F	3000	?	315-387	Trawling	Off Kelibia (Cape Bon)	Tunisia	10/2001	Unpubl. data
108	1	F	3000	?	584	Trawling	Barcelona	Spain	05/10/2001	Unpubl. data
109	1	F	±4000	±400	?	?	Gulf of Corinth	Greece	28/12/2001	Unpubl. data
110	1	?	± 2000	?	?	Beaching	Carro	France	01/2002	Unpubl. data
111	1	?	3750	400	?	?	Brucoli (Sicily)	Italy	03/03/2002	Unpubl. data
112	1	M	2270	?	220	Trawling	Gulf of Gabes	Tunisia	20/05/2002	Unpubl. data
113	65	F	940-4125	12-332	110-400	Longline	Algerian coast	Algeria	2000-2002	Unpubl. data
114	30	M	1280-3300	12-300	110-400	Longline	Algerian coast	Algeria	2000-002	Unpubl. data

## ZGODOVINSKI PREGLED PODATKOV O POJAVLJANJU MORSKEGA PSA ŠESTEROŠKRGARJA *HEXANCHUS GRISEUS* (BONNATERRE, 1788) (CHONDRICHTHYES: HEXANCHIDAE) V SREDOZEMSKEM MORJU

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### POVZETEK

Podatki o morskem psu šesteroškrjarju *Hexanchus griseus* iz literature in izvirnih zapisov iz različnih območij, še posebej pa iz obrežnih voda Francije, Španije, Italije, Malte in Tunizije, so v dobri meri pripomogli k boljšemu poznavanju nekaterih vidikov razširjenosti tega morskega psa v Sredozemskem morju. Trenutno bi lahko relativno številčnost morskega psa šesteroškrjarja v tem morju pripisali njegovim selitvam iz vzhodnega Atlantika skozi Giblarska vrata v Sredozemsko morje, poleg tega pa vse kaže, da *H. griseus* dejansko živi in se tudi razmnožuje v bližini magrebskih obrežij.

**Ključne besede:** Chondrichthyes, Hexanchidae, *Hexanchus griseus*, razširjenost, Sredozemsko morje

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## A GRAVID FEMALE BRAMBLE SHARK, *ECHINORHINUS BRUCUS* (BONNATERRE, 1788), CAUGHT OFF ELBA ISLAND (ITALY, NORTHERN TYRRHENIAN SEA)

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### ABSTRACT

A female bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788), estimated to be about 250 cm long, was caught around 1985 off Capo Bianco, Elba Island, Italy (western Mediterranean Sea). Dissection revealed at least 13 ova, measuring 8-10 cm in diameter. A list of 24 *E. brucus* specimens recorded from the Mediterranean Sea is presented, including historical and contemporary records. Most specimens (45.8%) have been reported from the Ligurian and Northern Tyrrhenian Seas; we hypothesize that *E. brucus* could reproduce in this area. The sex ratio is 1 : 3.3 males to females. A total of 11 *E. brucus* specimens are preserved in 9 European Natural History Museums. A 296 cm long female caught in 1856 off Nice, France, is close to the maximum size of this species, and a 258 cm male on display at Pavia Museum of Zoology is the largest of any Mediterranean specimen presently preserved. *E. brucus* is very rare in the Mediterranean and needs immediate protection in the entire area.

**Key words:** bramble shark, *Echinorhinus brucus*, reproduction, distribution, Mediterranean Sea

## UNA FEMMINA GRAVIDA DI RONCO SPINOSO, *ECHINORHINUS BRUCUS* (BONNATERRE, 1788), CATTURATA NELLE ACQUE DELL'ISOLA D'ELBA (ITALIA, MARE TIRRENO SETTENTRIONALE)

### SINTESI

Una femmina di ronco spinoso, *Echinorhinus brucus* (Bonnaterre, 1788), di circa 250 cm di lunghezza, fu catturata intorno al 1985 al largo di Capo Bianco, Isola d'Elba, Italia (Mare Mediterraneo occidentale). La dissezione rivelò almeno 13 uova di 8-10 cm di diametro. Viene presentata una lista di 24 esemplari di *E. brucus* catturati nel Mediterraneo in tempi storici e recenti. La maggior parte di esemplari (45.8%) sono stati registrati nei Mari Ligure e Tirreno Settentrionale; si ipotizza che *E. brucus* potesse riprodursi in quest'area. Il rapporto tra i sessi è di 1 : 3.3 = maschi : femmine. Un totale di 11 esemplari di *E. brucus* è conservato in 9 Musei Europei di Storia Naturale. Una femmina di 296 cm pescata nel 1856 al largo di Nizza, Francia, è vicina alla dimensione massima di questa specie, e un maschio di 258 cm del Museo di Zoologia di Pavia è il più grande esemplare Mediterraneo conservato attualmente. *E. brucus* è estremamente raro nel Mediterraneo e necessita immediata protezione nell'intera area.

**Parole chiave:** ronco spinoso, *Echinorhinus brucus*, riproduzione, distribuzione, Mare Mediterraneo.

## INTRODUCTION

The bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788) (Order Squaliformes, family Echinorhinidae), can be identified by its large and pointed dermal denticles (both singles and multiples, measuring up to 2.5 cm and widely spaced), stout body, massive caudal peduncle, lack of the anal fin, two dorsal fins (the origin of the first dorsal fin over pelvic fins), large pelvic fins, short pectoral fins, caudal fin without a posterior notch and with short lower lobe, long snout, large eyes, wide parabolic mouth, wide nostrils, small spiracles and 5 pairs of relatively small gill slits. Dorsal surfaces are dark grey, grey-brown to purple-reddish, with metallic hues and sometimes with black or reddish spots; ventral surfaces are lighter or whitish; dermal denticles are whitish. Both upper and lower teeth are relatively small, with a low oblique cusp and 2-4 cusplets. The dental formula is 10 to 13-10 to 13 / 11 to 1-1 to 14 (Fowler, 1936; Bigelow & Schroeder, 1948; Tortonese, 1956; Cadenat & Blache, 1981; Castro, 1983; Compagno, 1984; Last & Stevens, 1994; Moreno, 1995; De Maddalena, 2001; Barrull & Mate, 2002). The bramble shark's maximum size is about 310 cm (Compagno, 1984). Males mature at a length between 150 and 174 cm and females between 213 and 231 cm (Compagno, 1984). An aplacental viviparous species, the bramble shark has a litter size of 15 to 24 (Castro, 1983; Compagno, 1984). The gestation period is unknown. The size at birth is 29-90 cm (Compagno, 1984). This cartilaginous fish feeds on small sharks, bony fishes, cephalopods and crustaceans (Compagno, 1984; Moreno, 1995). The bramble shark is a timid and slow swimming species and usually occurs singly. This animal lives near or above the bottom on the continental and insular shelves and upper slopes, at depths between 18 and 900 m (Compagno, 1984).

The bramble shark's distribution includes the central and western Mediterranean Sea, Atlantic, Indian and Western Pacific Oceans (Cadenat & Blache, 1981; Compagno, 1984; Bauchot, 1987). Bramble sharks are characteristically rare in the entire Mediterranean Sea (Canestrini, 1874; Parona, 1898; Lo Bianco, 1909; Vinciguerra, 1923; Tortonese, 1938, 1956; Granier, 1964; Capapé, 1989; Barrull & Mate, 2002; Hemida & Capapé, 2002) and therefore difficult to study. As a result, little is known about their biology, ecology and behaviour. Our knowledge of reproduction in bramble sharks is rudimentary and few reports exist describing pregnant female of this species. We therefore report herewith on the capture of a gravid female *E. brucus* and present a list of specimens recorded from the Mediterranean Sea, in order to contribute to the knowledge of the bramble shark's reproduction and distribution.

## MATERIAL AND METHODS

This report is one of the various regional initiatives

that began following the formation of the Mediterranean Shark Research Group (MSRG), with the authors of this article being its active members. The collection of data concerning interesting captures and sightings of sharks along the Mediterranean coasts is conducted primarily by maintaining contacts with commercial fishermen, sport fishermen, divers, fish markets, researchers and marine life enthusiasts in the Mediterranean area. Through these contacts, substantial information on historical and recent records of sharks from the Mediterranean Sea are regularly collected.

Information concerning the capture and photographic evidence of a bramble shark caught off Elba Island were made available to us through Mr. Giuliano Chiocca. The picture is not of high quality mainly due to its poor reproduction. For this reason it is not possible to clearly observe some characteristics, such as dorsal fins' shape and ventral surfaces' colouration. Moreover, pectoral fins look strangely deformed, bent or damaged. Nevertheless, the species portrayed can be easily identified. Diagnostic features that are well visible on the photograph include: large and pointed dermal denticles on the dorsal surfaces, very massive caudal peduncle, lack of the anal fin, large pelvic fins, short caudal fin lower lobe, long snout, large eyes, wide parabolic mouth, evident labial furrows, wide nostrils nearly midway from mouth in preoral, upper and lower teeth with a low oblique cusp.



**Fig. 1: Map of Elba Island (Italy, western Mediterranean Sea), showing the location of the gravid bramble shark capture presented in this work. (Drawing: A. De Maddalena)**

**Sl. 1: Zemljevid Elbe (Italija, zahodno Sredozemlje) z označeno lokacijo, na kateri je bila ujeta breja samica bodičastega morskega psa, predstavljenega v tem članku. (Risba: A. De Maddalena)**

The species identification has been verified through comparison with photographs of a bramble shark caught off Annaba, Algeria (Hemida & Capapé, 2002) and three taxidermied specimens preserved in the Natural History Museums of Calci, Genoa, Italy and Prague, Czech Republic.

An additional search for historical and recent data on bramble sharks from the Mediterranean was effected by bibliographical research, location and study of materials preserved in Natural History Museums. For every case, whenever possible, the following data were collected: date and location of the capture, total length, weight and sex of the specimen, information on specimens preserved in museums and catalogue number in the collections.

### RESULTS AND DISCUSSION

A mature female bramble shark was caught by fishermen around 1985, between April and May, off Elba Island, in the Northern Tyrrhenian Sea (western Mediterranean Sea), Italy. She was caught in a net, at a depth of 70-80 m, off Capo Bianco (about 1 km north of Porto Azzurro), along the Eastern coast of Elba Island (G. Chiocca, *pers. comm.*) (Fig. 1). The specimen had a considerably distended belly. Dissection revealed numerous large ova.

The capture is supported by photographic evidence (Fig. 2). In fact, a colour photograph shows the shark lying inverted next to fisherman Raffaello Buono (a relative of one of the fishermen that caught the shark). We estimated the shark's length based on the size of Raffaello Buono, appearing in a bent over position on the photo (on the right side of the shark), and also on the size of the feet of three persons standing on the left side of the animal. We concluded that the bramble shark was about 250 cm total length. The source indicated an approximate weight of about 200 kg (G. Chiocca, *pers. comm.*) that, in our opinion, seems slightly exaggerated. The photograph shows the female bramble shark partially eviscerated. A number of large ova, at least 13, are well visible on the picture. We estimated the ova diameter was approximately 8-10 cm. The length of this pregnant female and her litter size fall within the range already known.

A list of *E. brucus* specimens recorded from the Mediterranean Sea is presented in Table 1. A total of 24 captures were available among historical and contemporary records (Fig. 3). For each specimen, the following data are reported: capture date, capture location, sex (M or F), total length in cm, weight in kg, data source and additional notes including catalogue number (Cat. No.) in the museum collections.

Most bramble shark specimens (11 or 45.8%) have been reported from the Ligurian and Northern Tyrrhenian Seas. Only 2 gravid females were recorded, both caught in Tyrrhenian Sea, in the Messina Strait and off

Elba Island, in 1937 and around 1985. An interesting detailed description of a 29.5 cm bramble shark embryo was given by Cipria (1937). No new-born specimen was recorded, with the possible exception of two specimens caught off Camogli, Italy, in 1951 and 1953. Therefore we can only hypothesize that *E. brucus* could reproduce in the Mediterranean Sea, perhaps in Ligurian and Tyrrhenian waters. Of the 24 specimens, 10 were females, 3 males and 11 of unknown sex. The sex ratio is 1 : 3.3 males to females. This numerical dominance of females may indicate some form of sex segregation, however, a large sample of adults is required before drawing any such conclusions.

Bramble sharks are rarely caught by professional fishermen operating in the study area, and are taken only as bycatch, caught accidentally while fishing for other commercial species. In the Mediterranean countries, *E. brucus* is considered of no importance for fishery.



**Fig. 2:** Approximately 250-cm female bramble shark, *Echinorhinus brucus* (Bonnaterre, 1788), caught off Elba Island, around 1985.

**Sl. 2:** Približno 250 cm dolga samica bodičastea morskega psa *Echinorhinus brucus* (Bonnaterre, 1788), ujeta okrog leta 1985 v bližini Elbe.



**Tab. 1: Bramble sharks, *Echinorhinus brucus* (Bonnaterre, 1788), caught in the Mediterranean Sea.**  
**Tab. 1: Bodičasti morski psi, *Echinorhinus brucus* (Bonnaterre, 1788), ujeti v Sredozemskem morju.**

Date	Location	Sex	Length (cm)	Weight (kg)	Source	Notes
1798	Nice (France)	-	-	200	Risso (1810)	-
1856	Nice (France)	F	296	-	Tortonese (1938)	Once preserved taxidermied in Milan Museum of Natural History (Cat. No. 2008).
May 1870	Palermo (Sicily, Italy)	-	-	-	Doderlein (1881), Sarà & Sarà (1990)	Once preserved taxidermied in Palermo Museum of Zoology. Maybe this is the one specimen still preserved in the museum (Cat. No. P 517 Coll. Doderlein).
July 1872	Palermo (Sicily, Italy)	-	-	-	Doderlein (1881), Sarà & Sarà (1990)	Once preserved taxidermied in Palermo Museum of Zoology. Maybe this is the one specimen still preserved in the museum (Cat. No. P 517 Coll. Doderlein).
April 1874	Palermo (Sicily, Italy)	-	-	-	Doderlein (1881), Sarà & Sarà (1990)	Once preserved taxidermied in Palermo Museum of Zoology. Maybe this is the one specimen still preserved in the museum (Cat. No. P 517 Coll. Doderlein).
May 1876	Livorno (Italy)	F	-	-	Vanni (1992)	Preserved taxidermied in Florence Museum of Zoology "La Specola" (Cat. No. 6041).
5 May 1877	Kvarner Gulf (Croatia)	M	162 (145)	-	Trois (1876), Mizzan (1994)	Preserved taxidermied in Venice Museum of Natural History "Fontego dei Turchi" (Cat. No. 7781); in Mizzan (1994) a different length is given.
Before 1879	Nice (France)	M	258	-	F. Barbagli ( <i>pers. comm.</i> )	Preserved taxidermied in Pavia Museum of Zoology (Cat. No. 854 Coll. Pesci).
26 June 1887	Genoa (Italy)	F	-	-	Vanni (1992)	Cranium preserved in Florence Museum of Zoology "La Specola" (Cat. No. 6355).
1898	Nice (France)	M	150	-	Šanda & De Maddalena (2003)	Preserved taxidermied in Prague Museum of Natural History (Cat. No. NMP6V 05253).
February 1904	Chioggia (Italy)	F	113	-	Ninni (1904), Mizzan (1994)	Preserved taxidermied in Venice Museum of Natural History "Fontego dei Turchi" (Cat. No. 7800).
Before 1909	Bocchicella (Italy)	F	180	-	Lo Bianco (1909)	Immature.
Before 1923	Italy (?)	-	-	-	Vinciguerra (1923)	Preserved taxidermied in Genoa University Museum of Zoology.
Before 1923	Italy (?)	-	-	-	Vinciguerra (1923)	Once preserved taxidermied in Genoa University Museum of Zoology.
22 May 1923	Noli (Italy)	F	240 (230)	80 (guttled)	Vinciguerra (1923), Tortonese (1956)	Preserved taxidermied in Genoa Museum of Natural History "G. Doria"; in Tortonese (1956) a slightly different length is given.
Before 1934	Palermo (Sicily, Italy)	F	193	-	Borri (1934)	Preserved taxidermied in Calci Museum of Natural History and the Territory.
22 July 1937	Messina Strait (Italy)	F	-	ca. 60	Cipria (1937)	Gravid. Litter size unknown.
July 1949	Golfe d'Aigues-Mortes (France)	-	-	-	Granier (1964)	-
1951	Camogli (Italy)	-	-	17.5	Boero & Carli (1979)	-
1953	Camogli (Italy)	-	-	13	Boero & Carli (1979)	-
Around 1980	Alboran Sea	-	-	-	Barrull & Mate (2002)	-
April-May, around 1985	Capo Bianco, Elba Island (Italy)	F	ca. 250	ca. 200	G. Chiocca ( <i>pers. comm.</i> )	Gravid. Litter size at least 13.
2 April 2000	Annaba (Algeria)	F	254	99 (guttled)	Hemida & Capapé (2002)	-
-	Nice (France)	-	-	-	P. Deynat ( <i>pers. comm.</i> )	Preserved taxidermied in Paris National Museum of Natural History (Cat. No. MNHN 0520).

A total of 11 *E. brucus* specimens are preserved in 9 European Natural History Museums located in Italy, Czech Republic and France. Preserved materials include 10 taxidermied specimens and one cranium. The female *E. brucus* caught in 1856 off Nice, France, and measuring 296 cm, is close to the maximum size reported in the literature for this species (about 310 cm according to Compagno, 1984). Unfortunately, the Museum of Natural History was destroyed during bombing raids on Milan during Second World War, between 13 and 15 August 1943 (Conci, 1980), and numerous specimens, including the large bramble shark, were lost. Therefore, to the best of our knowledge, a 258 cm long male caught before 1879 off Nice, France, on display in Pavia Museum of Zoology (Cat. No. 854 Coll. Pesci; F. Barbagli, *pers. comm.*), is the largest of any Mediterranean bramble shark presently preserved.

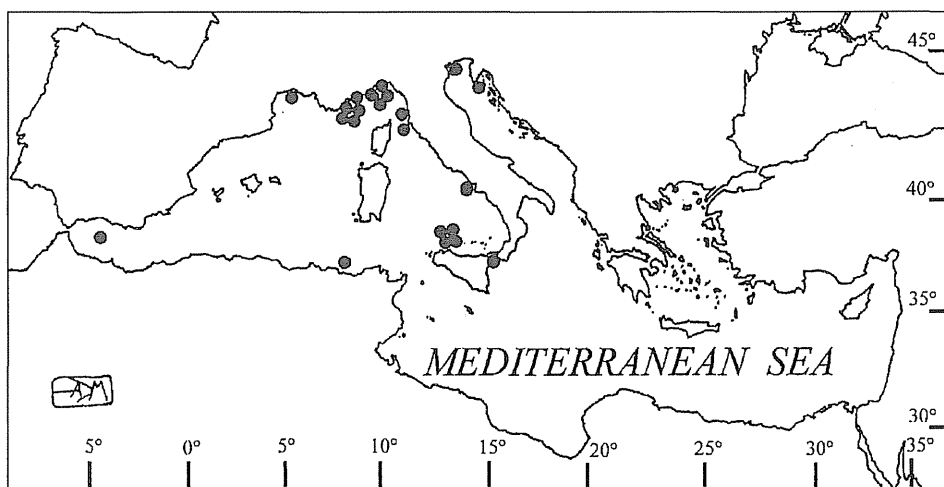
Bramble sharks have always been rare in the Mediterranean Sea. Most bramble shark specimens have been reported from Italian waters. Nevertheless, to the best of our knowledge, no specimens have been recorded in Italian waters since 1985. The alarming paucity of recent Mediterranean records of *E. brucus*, examined in a historical context, in fact infers that the species is very rare in these waters and, as Hemida & Capapé (2002) already noted, these sharks have almost disappeared from the entire region. In fact, among the species that have become particularly sporadic or rare due to overfishing of either sharks or their prey in the Mediterranean Sea, Cugini & De Maddalena (2003) cited the bramble shark, *E. brucus*, sandtiger shark, *Carcharias taurus*, smalltooth sand tiger, *Odontaspis ferox*, white shark, *Carcharodon carcharias*, shortfin mako, *Isurus oxyrinchus*, porbeagle, *Lamna nasus*, tope shark,

*Galeorhinus galeus*, sandbar shark, *Carcharhinus plumbeus*, blue shark, *Prionace glauca*, smooth hammerhead, *Sphyrna zygaena* and angular roughshark, *Oxyrinotus centrina*. The bramble shark has to be classified as a critically endangered species. Lack of management in the Mediterranean countries is leading to the extinction of several shark species. *E. brucus* needs immediate protection in the entire Mediterranean area.

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**Fig. 3: Distribution of historical and recent bramble shark *Echinorhinus brucus* captures in the Mediterranean Sea. (Drawing: A. De Maddalena)**

**Sl. 3: Zgodovinski in novejši podatki o bodičastih morskih psih *Echinorhinus brucus*, ujetih v Sredozemskem morju. (Risba: A. De Maddalena)**

### BREJA SAMICA BODIČASTEGA MORSKEGA PSA, *ECHINORHINUS BRUCUS* (BONNATERRE, 1788), UJETA V BLIŽINE ELBE (ITALIJA, TIRENSKO MORJE)

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#### POVZETEK

Okrog leta 1985 je bila v bližini Rta Bianco na Elbi (Italija, zahodno Sredozemsko morje) ujeta kakih 150 cm dolga samica bodičastega morskega psa *Echinorhinus brucus* (Bonnaterre, 1788). Njena notranjost je razkrila 13 jajc s premerom 8-10 cm. Avtorja predstavlja seznam 24 primerkov *E. brucus* iz Sredozemskega morja, skupaj z zgodovinskimi in novejšimi zapisi o teh redkih morskih psih. Večina osebkov (45,8%) je bila zabeležena v Ligurskem in severnem Tirenskem morju in avtorja domnevata, da bi se ta vrsta v tem območju utegnila tudi razmnoževati.

Razmerje med spoloma je bilo 1: 3,3 v korist samcev. V devetih evropskih naravoslovnih muzejih je ohranjenih 11 bodičastih morskih psov. 296 cm dolga samica, ujeta v bližini Nice, Francija, je najbrž največja predstavnica te vrste, medtem ko je 258 cm dolgi samec, razstavljen v Zoološkem muzeju v Pavii, največji od vseh ohranjenih sredozemskih primerkov. Bodičasti morski pes je zelo redek v Sredozemskem morju, to pa je razlog, da ga je treba pri priči zaščititi v celotnem območju.

**Ključne besede:** bodičasti morski pes, *Echinorhinus brucus*, razmnoževanje, razširjenost, Sredozemsko morje

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## HISTORICAL RECORDS OF THE GREAT WHITE SHARK, *CARCHARODON CARCHARIAS* (LINNAEUS, 1758) (LAMNIFORMES, LAMNIDAE), FROM THE SEA OF MARMARA

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### ABSTRACT

Fifteen historical records of the great white shark *Carcharodon carcharias* (Linnaeus, 1758), from the Sea of Marmara are presented. The available data suggest that the great white sharks used to be captured regularly in the Sea of Marmara in the period between the late 1800s and the late 1960s. The majority of sharks were accidentally captured by bluefin tuna (9 cases) and swordfish (1 case) hand-liners. Therefore, the occurrence of great white sharks is closely associated with pelagic fishery, especially with hand-lining of bluefin tuna *Thunnus thynnus*. Karakulak & Oray (1994) reported that the bluefin tuna had not occurred in the Black Sea and in the Sea of Marmara since 1987, which means that one of the great white shark's main preys became extinct in the above-mentioned seas. The seasonality of records has shown an increase in their occurrence during the winter months. In view of the last confirmed record of great white shark in the Sea of Marmara (in 1985), the species had been present in this sea until the last quarter of the 20<sup>th</sup> century.

**Key words:** Great white shark, *Carcharodon carcharias*, distribution, historical records, Sea of Marmara

## SEGNALAZIONI STORICHE DI SQUALO BIANCO, *CARCHARODON CARCHARIAS* (LINNAEUS, 1758) (LAMNIFORMES, LAMNIDAE), NEL MAR DI MARMARA

### SINTESI

L'articolo riporta quindici segnalazioni storiche di squalo bianco, *Carcharodon carcharias* (Linnaeus, 1758), nel Mar di Marmara. I dati disponibili suggeriscono che tra il tardo 1800 e la fine degli anni sessanta lo squalo bianco è stato catturato con regolarità nel Mar di Marmara. La presenza di squali bianchi viene collegata alla pesca del pesce pelagico, specialmente del tonno, *Thunnus thynnus*. Un incremento delle catture di squalo bianco è stato registrato durante i mesi invernali, quando tale specie ricerca acque più fredde. Visto che l'ultima cattura di squalo bianco nel Mar di Marmara risale al 1985, l'autore conclude che la presenza della specie in tale mare era certa fino all'ultimo quarto del ventesimo secolo.

**Parole chiave:** squalo bianco, *Carcharodon carcharias*, distribuzione, segnalazioni storiche, Mar di Marmara



## INTRODUCTION

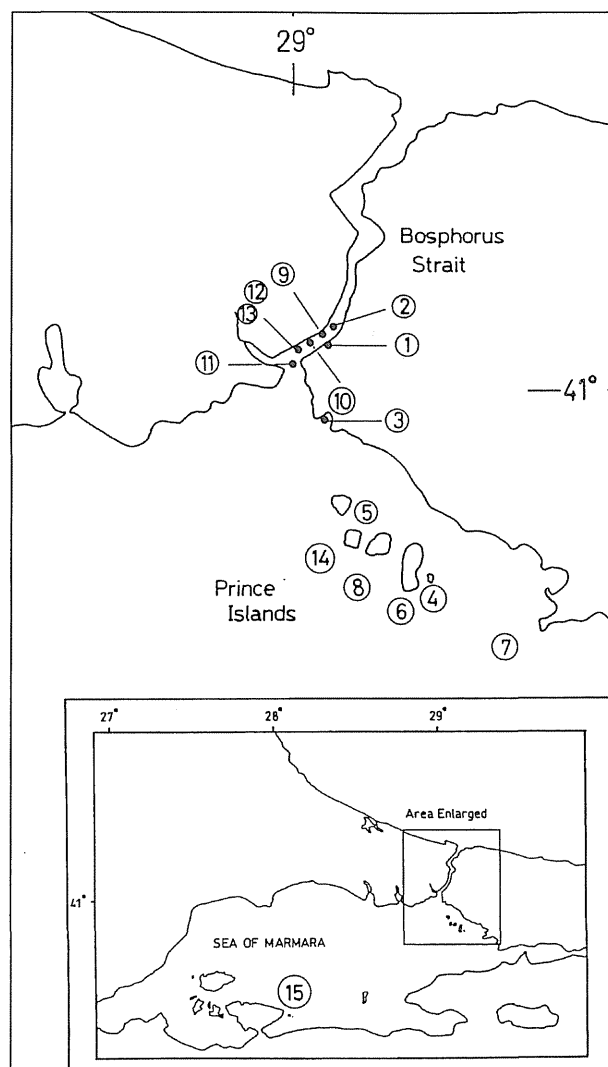
Great white shark, *Carcharodon carcharias* (Linnaeus, 1758) is a cosmopolitan species of coastal and temperate waters (Compagno, 1984). Its presence in the Mediterranean Sea has been well-documented in many general ichthyological or faunistic studies (for example Carus, 1889-1893; Riedl, 1983; Quéro, 1984; Bauchot, 1987), and has been broadly registered in many regional ichthyological works, for example, by Quignard & Capapé (1971) in Tunisian, Risso (1810) and Moreau (1881) in French, Tortonese (1956) and Bini (1967) in Italian, Papaconstantinou (1988) in Greek, and Ninni (1912) and Šoljan (1948) in Adriatic waters. Furthermore, general and regional distribution of the great white shark in the Mediterranean Sea as well as its historical and contemporary presence in the mentioned region has been investigated in detail (Fergusson, 1996; De Maddalena, 2000, 2002; Barrull & Mate, 2001; Celona *et al.*, 2001; Celona, 2002). One of the common aspects of these studies is, however, that the species is generally considered to be distributed in the western and central Mediterranean.

The first account on the presence of the great white shark in Turkish waters was made by Karakin Devedjian, former director of the İstanbul Fish Market at the beginning of the 20<sup>th</sup> century (Devedjian, 1926). In his pioneering study, Devedjian (1926) stated that the great white sharks (originally referred to as "*karkharias*" in his book) rarely landed at İstanbul fish market, and also gave some information on a captured specimen. In the general ichthyological work of Akşiray (1987), concerning Turkish marine fishes, its author stated the presence of *C. carcharias* in Turkish waters, but gave no information on the species distribution in the mentioned region. The presence of *C. carcharias* in Turkish waters has also been documented in the most recent lists of Turkish marine fishes by Mater & Meriç (1996), Bilecenoğlu *et al.* (2002) and Kabasakal (2002), whose last account deals exclusively with the elasmobranchs of Turkish seas. However, the available information on the historical and contemporary presence of the great white shark in Turkish waters still includes many uncertainties.

Although the presence of great white shark in the Sea of Marmara had been reported by Devedjian (1926), its historical records from this inland sea is remarkably limited, neither has it been included in the ichthyological lists of the Sea of Marmara (Ayaşlı, 1937; Erazi, 1942; Kocataş *et al.*, 1993). In the present study, a retrospective survey of the historical presence of great white shark in Marmaric waters, based on the available scientific and popular literature as well as interviews with fishermen, is presented.

## MATERIAL AND METHODS

The area encompassed by the present research is a subunit of the Mediterranean Sea and known as the Sea of Marmara (Fig. 1). It is linked with the Mediterranean Sea via the Dardanelles and with the Black Sea via the Bosphorus Strait. For this reason, while the surface waters of Marmara are affected by the Black Sea, its deeper layers remain under Mediterranean influence (Kocataş *et al.*, 1993). According to Öztürk & Öztürk (1996), the Sea of Marmara is an ecological barrier, a transition zone or an acclimatisation area, influencing the dispersal of the species between the Mediterranean and the Black Seas.



**Fig. 1: Localities of the recorded great white sharks in the Sea of Marmara. Circled numbers are the same as case numbers in Table 1.**

**Sl. 1: Lokalizacije zabeleženih belih morskih volkov v Marmarskem morju. Obkrožene številke so iste kot številke posameznih primerov v tabeli 1.**

Data on the historical presence of great white shark in Marmaric waters have been obtained from the following sources: (a) available scientific literature, (b) popular literature, such as newspapers, magazines, etc., and (c) interview with fishermen, especially with old tuna hand-liners, scuba divers or private citizens. Whenever possible, the following data were recorded for each specimen: date, locality of capture, total length (TL, in cm; TOT in Compagno, 1984), weight (W, in kg),

sex and type of capture. Photographs of some of these previous records have also been provided.

RESULTS

Fifteen historical records of *C. carcharias* have been determined from the Sea of Marmara. These records are summarised in Tab. 1.

Tab. 1: Summary of the historical records of *Carcharodon carcharias* from the Sea of Marmara. Case numbers are same as the circled numbers on Figure 1, showing approximate locations of captures.

Tab. 1: Povzetek zgodovinskih pojavljanj belega morskega volka *Carcharodon carcharias* v Marmarskem morju. Številke posameznih primerov ponazarjajo približne lokacije, kjer so bili morski psi ujeti, in so iste kot številke, obkrožene na sliki 1.

No.	DATE	LOCATION	TL (cm)	W (kg)	SEX	REMARKS	REFERENCE
1	February, 1881	Bosporus Strait	391	-	-	Stranded near Beylerbeyi coast	Fergusson (1996)
2	17 November 1881	Bosporus Strait	470	1500	♀	Captured; type of fishing gear unknown	Fergusson (1996)
3	1916	Sea of Marmara	ca. 700	-	-	Entrapped in Salistra fish trap; shot by fishermen with 3 bullets in its head.	Devedjian (1945)
4	May 1920	Sea of Marmara	465	ca. 1200	-	Captured off the coast of Sedef adası; a bluefin tuna, weighing ca. 200 kg, remains of a swordfish, a few bonitos, and a small stone found in its stomach.	Devedjian (1945)
5	before 1926	Sea of Marmara	ca. 400	-	-	Eight large bonitos found in its stomach.	Devedjian (1926)
6	20 February 1926	Sea of Marmara	450	over 1500	-	Captured off the coast of Büyükada (Fig. 2)	Agop Savul, pers. comm.
7	30 March 1954	Sea of Marmara	450	1500	-	Captured off the coast of Tuzla (Fig. 3)	Agop Savul, pers. comm.
8	15 April 1956	Sea of Marmara	618	ca. 3000	♀	Captured off the coast of Prince Islands; its mass surely miss-estimated	Agop Savul, pers. comm.
9	February 1962	Bosporus Strait	500+	3750	♀	Mass surely miss-estimated	Fergusson (1996)
10	28 December 1965	Bosporus Strait	500	ca. 4000	♀	Captured off the coast of Dolmabahçe; mass surely miss-estimated	Agop Savul, pers. comm.
11	28 December 1965	Bosporus Strait	700	ca. 3000	♀	Captured near Maiden's Tower (Fig. 4)	Agop Savul, pers. comm.
12	13 January 1966	Bosporus Strait	ca. 400	ca.2000	-	Harpooned off the coast of Kabataş (Fig. 5)	Agop Savul, pers. comm.
13	13 January 1966	Bosporus Strait	ca. 400	ca. 2000	-	Harpooned off the coast of Kabataş (Fig. 5, belly of the second specimen shown overturned on the left of the picture)	Agop Savul, pers. comm.
14	before 1974	Sea of Marmara	-	ca. 2000	-	Captured off the coast of Prince Islands	Güney (1974)
15	May 1985	Sea of Marmara	ca. 500	-	-	Sighted off the coast of Kapıdağ peninsula	Kabasakal (unpublished data)

Although the dates of two records of *C. carcharias* from the Bosphorus Strait by Fergusson (1996) are earlier (both in 1881) than those of Devedjian (1926), the former author has not given any detailed information on the presence of great white sharks in Turkish waters. However, concerning the 3 data reported by Fergusson (1996), two of which were reported without source and the third as a personal communication from G. Wood, a confirmation of these recordings from the Sea of Marmara is strongly required, as some other data presented by the same author from the Mediterranean Sea, especially its western basin, have been indicated as unreliable by Barrull & Mate (2001) and Celona *et al.* (2001).

In 1916, an enormous great white shark (700 cm TL) entered the Salistra fish trap near Fenerbahçe harbour (northern Sea of Marmara) (Devedjian, 1945; case No. 3 in Tab. 1). The shark, entangled in the nets and ropes of the fish trap, was killed by fishermen after shot three times in its head. According to the author, it was impossible to transport the shark to the auction place of the fish market, so it was eviscerated and cut at the fish trap and sold. Devedjian (1945) stated that its head only weighed nearly 200 kilograms. Since there are very few records from all over the world on great white sharks exceeding the length of 650 cm (Compagno, 1984), the size of this individual (700 cm), as estimated by Devedjian (1945), seems unreliable.

On May of 1920, another great white shark (465 cm TL and weighing nearly 1,200 kg) was been captured with a swordfish line off the coast of Sedef adası (Devedjian, 1945; case No. 4 in Tab. 1). This specimen, whose stomach contents are presented in Tab. 1, was displayed at the İstanbul Fish Market for a long time. Devedjian (1945) stated that the length of each pectoral fin of the specimen was 80 cm and the height of the first

dorsal fin 60 cm. A capture of another great white shark prior to 1926 was also reported by Devedjian (1926). Total length of this specimen (case No. 5 in Tab. 1) was 400 cm, and it was landed at the İstanbul Fish Market. Devedjian (1926) reported that 8 large bonitos were found in the stomach contents of this specimen and that the width at the widest part of its body was 135 cm. According to Devedjian (1926), the meat of great white sharks captured in İstanbul waters (northern Sea of Marmara) is seldom consumed by people.

Another great white shark (450 cm TL) was captured on 20 February 1926 off the coast of Büyükdada (Fig. 2; case No. 6 in Tab. 1), with its reported weight exceeding 1,500 kg (Agop Savul, *pers. comm.*).

On 30 March 1954, a great white shark (450 cm TL and 1,500 kg W) was captured by a tuna hand-liner off the coast of Tuzla (Agop Savul, *pers. comm.*; Fig. 3, case No. 7 in Tab. 1). This shark, too, was displayed at the İstanbul Fish Market for a long time. Two years later, on 15 April 1956, an enormous great white shark (618 cm



Fig. 2: 450 cm TL specimen captured off the coast of Büyükdada (case No. 6) (Agop Savul's archive).

Sl. 2: 450 cm (TL) dolgi primerek, ujet v bližini Büyükdade (primer št. 6) (arhiv Agopa Savula).



Fig. 3: 450 cm TL specimen captured off the coast of Tuzla (case No. 7) (Agop Savul's archive).

Sl. 3: 450 cm (TL) dolgi primerek, ujet v bližini turškega obmorskega mesteca Tuzla (primer št. 7) (arhiv Agopa Savula).

TL and 3000 kg W) was captured by a tuna hand-liner, Aziz Ünlü, off the coast of Prince Islands in the northern Sea of Marmara (Agop Savul, *pers. comm.*; case No. 8 in Tab. 1). While he was cruising along the coast of Prince Islands during the early morning hours, the mentioned great white shark was hooked, and he was able to harpoon it only after a 7-hour fighting with the shark.

Six years later, on February 1962, another great white shark (500+ cm TL and 3750 kg W) was captured in the Bosphorus Strait (Fergusson, 1996; case No. 9 in Tab. 1). Fergusson (1996) stated that the mass of this specimen had surely been miss-estimated. On 28 December 1965, another great white shark (500 cm TL and 4000 kg W) was captured by three fishermen in the Bosphorus Strait during bluefin tuna fishing. After a long and hard fight, the fishermen harpooned the shark and landed it on Dolmabahçe coast (Agop Savul, *pers. comm.*; case No. 10 in Tab. 1). On the same day, another great white shark (700 cm TL and nearly 3000 kg W) was caught by Hüseyin Şalvarlı off the coast of Maiden's Tower in southern part of the Bosphorus Strait

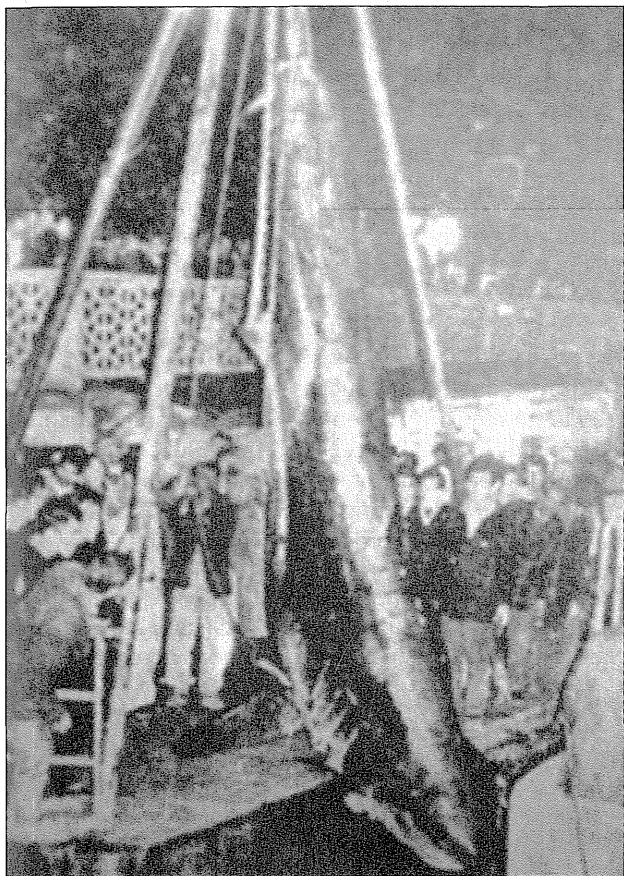
(Agop Savul, *pers. comm.*; Fig. 4, case No. 11 in Tab. 1). After capturing a bluefin tuna (weighing nearly 390 kg) he dropped his line into the water, but this time the mentioned great white shark was hooked. The shark towed the small fishing boat in the Strait for quite some time, but finally the fisherman succeeded in gaffing the shark with the anchor of his boat. On 13 January 1966, two great white sharks (both 400 cm TL and 2000 kg W) were captured in the Bosphorus Strait by Hakkı Baba and Ali Yavur, fishermen from Karaköy Port, İstanbul. After 4.5 hours of fighting, the fishermen harpooned the sharks near Kabataş coast (Agop Savul, *pers. comm.*; Fig. 5, case nos. 12 & 13 in Tab. 1). No great white sharks have been captured neither in the Sea of Marmara nor in the Bosphorus Strait between 1966 and 1974. The capture of a great white shark, weighing nearly 2000 kg, off the coast of Prince islands in northern Marmara has been reported by Güney (1974), however, the exact date of capture of this specimen is uncertain (case No. 14 in Tab. 1).

One of the more recent records of the great white shark in the Sea of Marmara is dated to 1985. A specimen, nearly 500 cm in total length, was sighted by a fisherman off the north-eastern coast of Kapıdağ peninsula (southern Sea of Marmara, Fig. 1) (case No. 15 in Tab. 1). The fisherman stated that the shark had circled around his boat for a few minutes and then disappeared (Agop Savul, *pers. comm.*).

## DISCUSSION

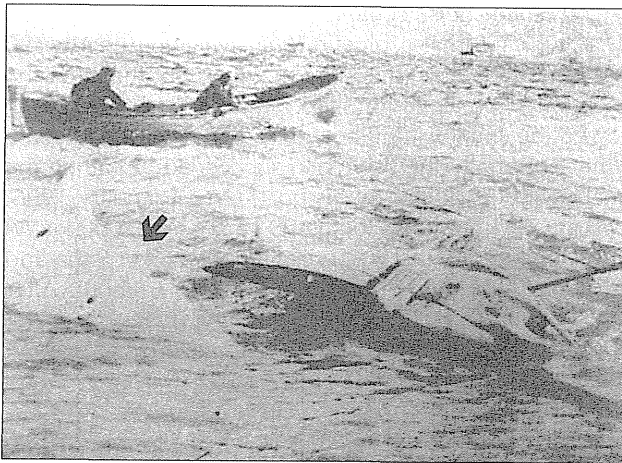
As it can be seen from the above data, all but one (No. 15 in Tab. 1) great white sharks were reported from northern Marmaric waters, around Prince Islands and southern Bosphorus Strait (Fig. 1). Besides the entrapped specimen in Salistra fish trap (case No. 3 in Tab. 1), the three records by Fergusson (1996; case nos. 1, 2 & 9 in Tab. 1) who gave no information on the type of their capture, and the specimen sighted off the coast of Kapıdağ peninsula while swimming near the surface (case No. 15 in Tab. 1), the remaining 10 great white sharks were accidentally captured by bluefin tuna (9 cases) and swordfish (1 case) hand-liners. Accidental captures of great white sharks are therefore closely associated with artisan fishery (hand-lining) of the bluefin tuna.

Although the abundance of bluefin tuna, *Thunnus thynnus*, reaches its peak in pre-Bosporic waters of the Black Sea and in the Bosphorus Strait especially in July, this period may be extended to the end of August. Bluefin tunas migrate towards the Aegean Sea from October to the end of December (Akşiray, 1987; Karakulak & Oray, 1994). However, in some years, when air and sea winter temperatures are higher than usual averages, some bluefin tunas do not continue with their southwestern migration, but overwinter in the waters of Prince Is-



**Fig. 4: 700 cm TL specimen captured near Maiden's Tower (case No. 11) (Agop Savul's archive).**

**Sl. 4: 700 cm (TL) dolgi beli morski volk, ujet v bližini Dekliškega stolpa (primer št. 11) (arhiv Agopa Savula).**



**Fig. 5: 400 cm TL specimens harpooned off the coast of Kabataş, with arrow indicating the belly of the second specimen overturned on the left of the photograph (case Nos 12 & 13) (Agop Savul's archive).**

**Sl. 5: 400 cm (TL) dolga primerka, harpunirana blizu Kabataşa; puščica kaže na trebuh drugega primerka, obrnjenega na hrbtu na levi strani fotografije (primeri št. 12 in 13) (arhiv Agopa Savula).**

lands and in the channel area of the Bosphorus Strait (Üner, 1984). Güney (1974) and Üner (1984) reported that the great white sharks were rarely seen entering the Bosphorus Strait, while in pursuit of bonitos and bluefin tunas. Accidental capture of these predatory sharks in the waters of Prince Islands and in the Bosphorus Strait was usually a consequence of the great white sharks chasing these large bony fishes (Üner, 1984). Karakulak & Oray (1994) reported that the bluefin tuna had not occurred in the Black and Marmara Seas since 1987, which means that one of the great white shark's main preys became extinct in the mentioned seas. The latest recording of the great white shark from the Sea of Marmara (1985, case No. 15 in Tab. 1) remarkably correlates with the latest recording of the bluefin tunas from the same area (1987). Still, such situation in the area may be due to: (1) the absence of one of their main prey, bluefin tuna, in the Sea of Marmara and owing to the great white sharks not entering this sea at least since their last recording, or (2) great white sharks are still present in the Sea of Marmara but there has been no accidental capture of this species due to the disuse of bluefin tuna lines (or lines for other large bony fishes). Some extensive investigations would be thus required to give reliable answers to the above questions.

Akşiray (1987) reported that great white sharks had been absent in the Sea of Marmara and in the Bosphorus Strait for the last 20 to 25 years. Regarding the year of publication of his book (1987), this span covers the period between 1962 and 1967. Despite Akşiray's suggestion, at least one great white shark was captured or

sighted in 1974 and 1985 (case nos. 14 & 15 in Tab. 1).

With the exception of 5 cases (case nos. 3, 4, 5, 14 & 15 in Tab. 1), the great white sharks were captured between mid-November and mid-April. Two of the 5 cases (nos. 4 & 15 in Tab. 1) were captured in May, while the date of capture of the remaining 3 specimens is unknown. Üner (1984) reported that great white sharks were captured in the waters of Prince Islands and Bosphorus Strait from December to the end of March, but added that this period could vary depending on temperature of the sea. Still, no great white sharks were captured or sighted in the Sea of Marmara between May and November (or December). Annual temperatures of the Sea of Marmara surface waters range from 4 to 24°C, while during November and April, when the accidental captures of great white sharks reached their peak, they range from 7°C (November) and 21°C (April). Great white sharks are known to occur in waters with temperatures ranging from 7 to 27°C (mainly 15 to 22°C) (Nakaya, 1994). The thermal tolerance of this species is demonstrated by its latitudinal distribution (Compagno, 1984). In the Catalanian Sea, the seasonality of great white shark recordings showed an increase during the winter months and it has been suggested that this is due to the great white sharks searching for colder waters (Barrell & Mate, 2001). Eurythermal nature of the great white shark suggests that the species can remain in Marmaric waters all year round and that winter presence of these sharks in surface waters and their summer presence in deeper parts of the Sea of Marmara are therefore probably the result of this species searching for cold waters.

## CONCLUSIONS

The available data suggest that great white sharks used to be regularly although somewhat rarely captured in Marmaric waters between the late 1800s and the late 1960s. The seasonality of records has shown an increase in their occurrence during the winter months. In view of the last confirmed record of this shark in the Sea of Marmara (in the year 1985), the species had been present in this sea until the last quarter of the 20th century. The occurrences as well as capture of great white sharks are closely associated with pelagic fishery, especially with hand-lining of bluefin tuna. Bluefin tunas, one of the great white shark's main preys, are known to have been absent in the Sea of Marmara since 1987. Because of this reason, hand-lining of this large pelagic bony fish was also abandoned in Marmaric and Bosphoric waters at least 25 years ago. Although commercial purse-seining vessels still operate in the Sea of Marmara for capturing bonito, *Sarda sarda*, bluefish, *Pomatomus saltator*, and other pelagic bony fishes, no current capture record of the great white shark has been reported by these vessels from Marmaric waters. The available data suggest that great white sharks no longer occur in the Sea of Marmara. Ex-



tensive investigations and cooperation with commercial fishermen are required in order to clarify the current status of this apex predator in this small inland sea.

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## ZGODOVINSKI PODATKI O POJAVLJANJU BELEGA MORSKEGA VOLKA *CARCHARODON CARCHARIAS* (LINNÉ, 1758) (LAMNIFORMES, LAMNIDAE) V MARMARSKEM MORJU

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#### POVZETEK

Avtor članka navaja petnajst zgodovinskih podatkov o pojavljanju belega morskega volka *Carcharodon carcharias* (Linné, 1758) v Marmarskem morju (Turčija). Zapis, ki so mu bili na voljo, govori, da so te morske pse lovili kar redno, čeprav ne ravno pogosto, med koncem 19. stoletja in koncem 60. let dvajsetega stoletja. Večina teh morskih plenilcev je bila ujeta naključno, in sicer ročno z vrstico med lovom na tuna (9 primerov) in mečarico (1 primer). Pojavljanje belega morskega volka je zatorej tesno povezano s pelaškim ribištvom, posebno lovom na tuna *Thunnus thynnus*. Karakulak & Oray (1994) sta poročala, da se ta tun ne pojavlja v Črnem in Marmarskem morju že od leta 1987, kar seveda pomeni, da je najpomembnejši plen belega morskega volka kratko malo izumrl v omenjenih dveh morjih. Sicer pa čas, v katerem so bili ujeti ti morski psi, kaže na to, da so se pogostejše pojavljali v zimskih mesecih. Glede na zadnje potrjeno pojavljanje belega morskega volka v Marmarskem morju (iz leta 1985) vse kaže, da je ta beli morski volk živel v tem morju do zadnje četrtine dvajsetega stoletja.

**Key words:** beli morski volk, *Carcharodon carcharias*, razširjenost, zgodovinski podatki, Marmarsko morje

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## EFFECTS OF REPRODUCTIVE FACTORS ON INTERRELATIONSHIPS BETWEEN THREE DEEP WATER SHARKS FROM NORTHERN TUNISIA (CENTRAL MEDITERRANEAN)

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### ABSTRACT

Three deep water sharks are known to occur in the waters off the northern Tunisian coast: the blackmouth cat-shark *Galeus melastomus* (Rafinesque, 1810), the gulper shark *Centrophorus granulosus* (Schneider, 1801) and the velvet belly *Etmopterus spinax* (Linnaeus, 1758). They all inhabit similar biotopes. Competition for food may be inferred among the three squalid species, but sufficient food is available in these areas. Moreover, morphological characteristics, such as size at first sexual maturity, maximal size, fecundity and reproductive mode, viviparity and oviparity, are different for each species. These characteristics considerably reduce the inferred competition for food in the area between the three species. They allow the three sympatric deep-water sharks to live and reproduce off northern Tunisia.

**Key-words:** deep water sharks, *Etmopterus spinax*, *Galeus melastomus*, *Centrophorus granulosus*, prey composition, biological factors, interrelationships, northern Tunisia, Mediterranean

## EFFETTI DI FATTORI RIPRODUTTIVI SU INTERRELAZIONI TRA TRE SPECIE DI SQUALI DI ACQUE PROFONDE IN TUNISIA SETTENTRIONALE (MEDITERRANEO CENTRALE)

### SINTESI

Tre specie di squali di acque profonde sono note al largo della costa settentrionale della Tunisia: il boccanera *Galeus melastomus* (Rafinesque, 1810), il centroforo *Centrophorus granulosus* (Schneider, 1801) ed il moretto *Etmopterus spinax* (Linnaeus, 1758), che occupano biotopi simili. Si può pertanto supporre una competizione per il nutrimento tra le tre specie di squalidi, benché in tali aree sia disponibile una quantità sufficiente di cibo. Inoltre, caratteri morfologici quali la taglia alla prima maturità sessuale, la taglia massima, la fecondità e la modalità di riproduzione, ovipara e vivipara, sono differenti per tali specie. Questi caratteri riducono ulteriormente la possibile competizione per il nutrimento nell'area fra queste tre specie, permettendo loro di vivere e riprodursi nelle acque al largo della Tunisia settentrionale.

**Parole chiave:** squali di acque profonde, *Etmopterus spinax*, *Galeus melastomus*, *Centrophorus granulosus*, composizione delle prede, fattori biologici, interrelazioni, Tunisia settentrionale, Mediterraneo

## INTRODUCTION

According to Quignard & Capapé (1971), Capapé (1989) and Bradaï (2000), three deep water sharks are known to occur off the northern Tunisian coast (Fig. 1): the blackmouth catshark *Galeus melastomus* (Rafinesque, 1810), the gulper shark *Centrophorus granulosus* (Schneider, 1801) and the velvet belly *Etmopterus spinax* (Linnaeus, 1758).

They are usually caught at depths exceeding 400 m with quite unfavourable abiotic parameters and not very high biological diversity, and involve an interspecific competition pressure especially with regard to the three sympatric deep water sharks, active predators and voracious feeders as other elasmobranch species (Capapé, 1976).

Nevertheless, commercial and scientific trawlings conducted in deep waters off the northern Tunisia have shown that the three shark species are concomitantly captured together in relative abundance. Moreover, for each species, juvenile and adult males and females have been collected. Adult females bearing encapsulated eggs or embryos and different stages of development have also been examined. These records suggest that the three sympatric species are probably able to live and reproduce in the same area, although interspecific competition pressure is probably inferred and cannot be totally neglected.

In order to answer this question, two separate analyses were conducted.

The first analysis was to compare prey composition of the diet in *E. spinax*, *G. melastomus* and *C. granulosus*. Diet composition of *G. melastomus* and *C. granulosus* from off the northern Tunisian coast had been previously studied (Capapé & Zaouali, 1976; Capapé, 1985). However, little is known about food and feeding habits of *E. spinax* from the area and only general data were provided (Capapé, 1975). Further observations allow to

expand upon the previous data. In the present work, we first of all present a conventional content analysis (qualitative) of *E. spinax* from the northern Tunisian coast and examine the role of seasonal, sexual and ontogenic factors on its diet, which are compared with those of its two sympatric species.

The second analysis was to compare some aspects of the reproductive biology of sharks, which had been previously studied for the blackmouth catshark (Capapé & Zaouali, 1977; Tursi *et al.*, 1993), the gulper shark (Capapé, 1985; Golani & Pisanty, 2000) and the velvet belly (Hickling, 1963; Vacchi & Orsi Relini, 1979; Kabasakal & Unkal, 1999; Capapé *et al.*, 2001; De Madalena & Piscitelli, 2001), and to explain their role in the interrelationships between the three sympatric deep water sharks captured off northern Tunisia.

## MATERIAL AND METHODS

Velvet bellies were collected by means of trawlings on the Bank of Esquerquis (northern Tunisia) and off the northern coast of Tunisia between 1978 and 1990. Of the 120 captured specimens, 43 males (27 juveniles and 16 adults) and 77 females (63 juveniles and 14 adults) were recorded. Digestive tracts were removed and examined for food items.

Two qualitative parameters were used to analyse stomach contents:

- percent of occurrence (PO) indicating the percent of stomachs with food items or with remains of food items (Tab. 1);

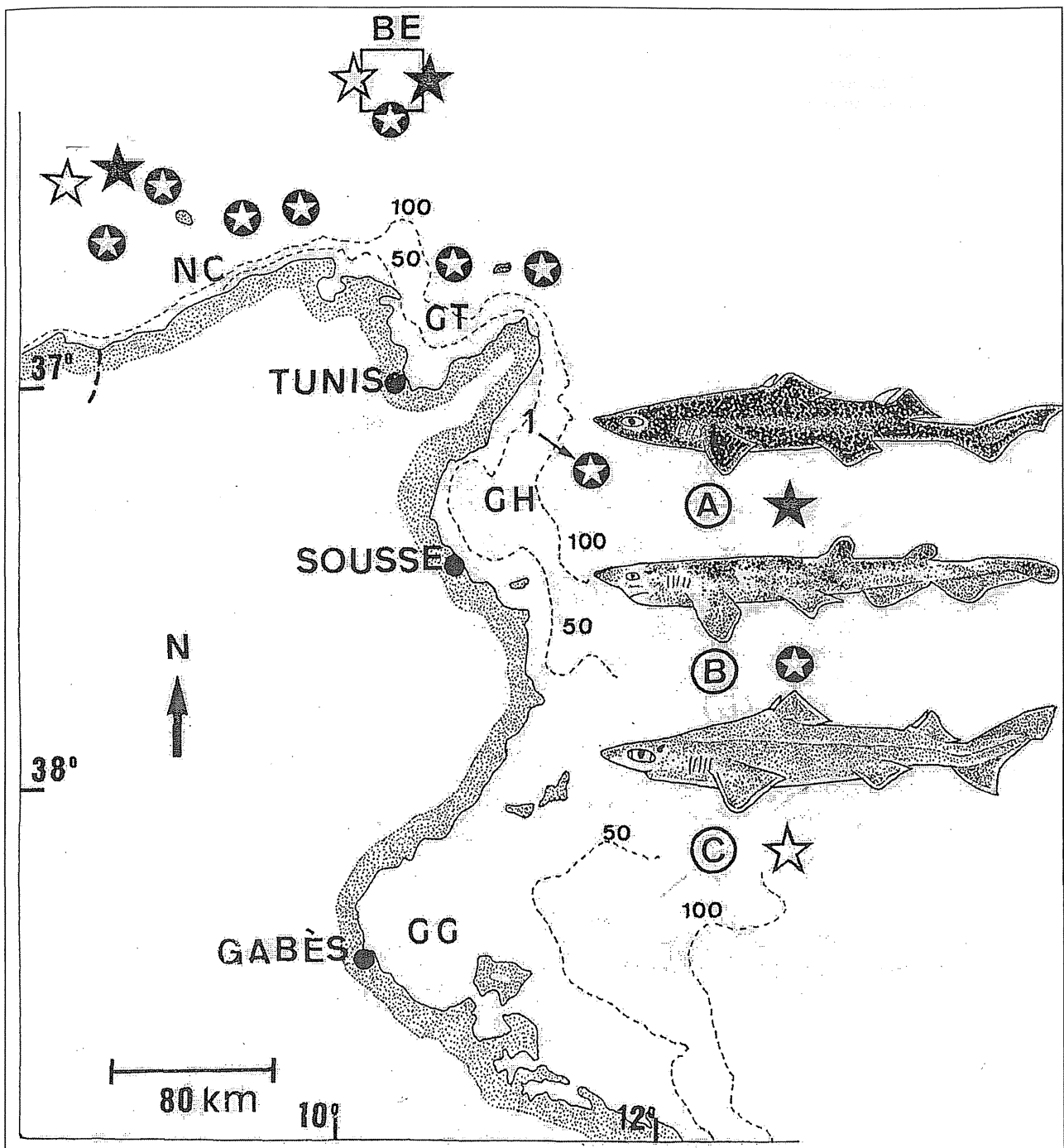
- frequency index of zoological group preys (FI) indicating the number of times a zoological group is found in stomach contents related to the total number of full stomach contents examined (Tab. 2).

Food items were identified at generic and specific levels when possible. Zoological groups found in *E. spinax* stomach contents are listed in Table 3.

**Tab. 1: Percent of occurrence of food items in stomach contents of *Etmopterus spinax* for sex, category and season.**

**Tab. 1: Delež polnih želodcev morskih psov vrste *Etmopterus spinax* glede na spol, starostno kategorijo in sezono.**

Sex	Males						Females						General total
Category	Juveniles			Adults			Juveniles			Adults			
Season	Sum	Win	Annual total	Sum	Win	Annual total	Sum	Win	Annual total	Sum	Win	Annual total	
Stomachs examined	14	13	27	9	7	16	32	31	63	12	2	14	120
Stomachs with food	12	10	22	7	6	13	26	27	53	10	2	12	100
Percent of occurrence	86	77	81	77	86	81	81	87	84	83	100	86	83



**Fig. 1:** Geographic distribution along the coast of Tunisia of (A) *Etmopterus spinax*, (B) *Galeus melastomus* and (C) *Centrophorus granulosus*. BE: Bank of Esquerquis, GG: Gulf of Gabès, GH: Gulf of Hammamet, GT: Gulf of Tunis, NC: Northern Coast. Arrow 1 points at the site of *G. melastomus* recorded for the first time in GH (see Bradai et al., 2000).

**Sl. 1:** Geografska razširjenost obravnavanih morskih psov vzdolž tunizijske obale: (A) *Etmopterus spinax*, (B) *Galeus melastomus* in (C) *Centrophorus granulosus*. BE: Banc des Esquerquis, GG: Gabeški zaliv, GH: Hammameški zaliv, GT: Tuniški zaliv, NC: severna obala. Puščica 1 kaže na lokaliteto v Hammameškem zalivu, kjer je bil prvič zabeležen *G. melastomus* (glej Bradai et al., 2000).



Males and females, with juveniles and adults among them, are examined separately. The specimens larger than the size at first sexual maturity, which is reached by velvet bellies in Tunisian waters at about 350 mm and 380 mm TL by males and females, respectively, were considered as adults (Capapé *et al.*, 2001).

The specimens were grouped into seasonal categories corresponding to the period of the year when the trawling surveys were made: summer (Sum), from June to September and winter (Win), from December to February.

Tests for significance were assessed for t-test ( $p < 0.01$ ).

## RESULTS

Twenty stomachs were empty and the mean value of percent of occurrence (PO) was 83. The PO of juvenile and adult males and females had high value from 77 to 87 (Tab. 1). However, seasonal variation is not clearly evident except in juvenile males.

Crustaceans, cephalopods and teleosts were the most important preys and their occurrence in the stomach contents showed seasonal variation. Annelids and elasmobranchs were poorly represented (Tab. 2).

The crustacean species were best represented, of the seven identified species *Aristeus antennatus* (9), *Pontophilus spinosus* (9) and *Plesionika martia* (12) were most often recorded in the stomach contents. Three cephalopod species were identified, *Sepia elegans* (5), *Sepietta oweniana* (11) and *Sepiolo* sp. (2) and of the six teleost species identified, *Ichtyococcus ovatus* (9), *Myctophum punctatum*, *Gadiculus argenteus* (5) were most frequently consumed by *E. spinax* (Tab. 3).

Some annelid worms, crustaceans, cephalopods and teleosts were unidentified, as they were represented by remains of food.

Moreover, two elasmobranch species were identified. Small specimens and three egg-capsules of *G. melastomus*, but also two *E. spinax* newborns with remains of an internal vitellin vesicle and umbilical scar were present in stomach contents.

**Tab. 2: Frequency index (FI) of zoological groups ingested by *Etmopterus spinax* for sex, category and season.**

**Tab. 2: Frekvenčni indeks (FI) posameznih skupin živali glede na spol, starostno kategorijo in sezono, ki jih je plenil morski pes *Etmopterus spinax*.**

Sex	Males						Females						General total
Category	Non-adults			Adults			Non-adults			Adults			
Season	Sum	Win	Annual total	Sum	Win	Annual total	Sum	Win	Annual total	Sum	Win	Annual total	
Crustaceans	8* (0.66)	8 (0.61)	16 (0.73)	1 (0.14)	0	1 (0.08)	20 (0.77)	16 (0.59)	36 (0.68)	2 (0.2)	0	2 (0.16)	55 (0.55)
Cephalopods	2 (0.16)	5 (0.23)	7 (0.32)	2 (0.28)	0	2 (0.16)	4 (0.15)	6 (0.22)	10 (0.19)	2 (0.20)	0	2 (0.16)	21 (0.21)
Teleosts	4 (0.33)	2 (0.15)	6 (0.27)	6 (0.86)	4 (0.57)	10 (0.77)	4 (0.15)	5 (0.18)	9 (0.17)	6 (0.6)	2 (1.0)	8 (0.66)	33 (0.33)
Other groups	1 (0.08)	0	1 (0.04)	1 (0.14)	2 (0.28)	3 (0.23)	0	1 (0.04)	1 (0.02)	2 (0.2)	0	2 (0.16)	10 (0.10)

\* number of times a prey belonging to a zoological group is ingested

## DISCUSSION

The mean value of percent of occurrence (83, see Table 1) indicates that *E. spinax* is an active predator and voracious as other elasmobranch species and agrees with McPherson (1980). However, only five zoological items were reported from *E. spinax* stomach contents and for each of them few species were recorded. This suggests that the species is rather opportunist and feeds on the most abundant food items available in their environment; the velvet bellies being restricted to deep bottoms where biological environment does not present a high diversity. The variation of frequency incidence among zoological items in juveniles and adults suggests a change in food and feeding habits and prey selectivity in *E. spinax* according to the category of specimens

(Tab. 2). For instance, the adults ingested more cephalopods and teleosts than the juveniles. This may be due to the fact that larger specimens were more active predators and experienced feeders. Moreover, depth segregation with sex and size cannot be neglected. With regard to this point, Orsi Relini & Würtz (1977) wrote: "The young of *Etmopterus spinax* have also been observed on epybathyal bottoms (about 450 m) in late spring, whilst the adults are observable in varying numbers at 500 meters, throughout the year."

Our observations of *E. spinax* agree with previous papers referring to items ingested but they differ at specific level. This difference could be related to the available species between the areas and depths involved.

Tab. 3: List of prey species identified in stomachs contents of *Etmopterus spinax*.

Tab. 3: Seznam vrst plena, določenih v želodcih morskega psa *Etmopterus spinax*.

Sex	Males				Females				Total
Category	Juveniles		Adults		Juveniles		Adults		
Season	Sum	Win	Sum	Win	Sum	Win	Sum	Win	
Stomachs examined	14	13	9	7	32	31	12	2	120
Annelids									
unidentified	1					1	1		3
Crustaceans									
<i>Aristeus antennatus</i>	1				6	2			9
<i>Chlorotocus crassicornis</i>	1				2	2			5
<i>Plesionika heterocarpus</i>	1	1			1	2			5
<i>P. martia</i>	2		1		2	1			6
<i>P. edwardsii</i>				1	2	1			4
<i>Pontophilus spinosus</i>		2			3	3	1		9
<i>Goneplax rhomboides</i>		2		1	3	3			9
unidentified	3	3			1	2	1		10
Cephalopods									
<i>Sepia elegans</i>	1		1		2	1			5
<i>Sepiola</i> sp.			1				1		2
<i>Sepietta oweniana</i>	1	3	1			5	1		11
unidentified		2			2				4
Elasmobranchs									
<i>Galeus melastomus</i>				2		1	2		5
<i>Etmopterus spinax</i>			1				1		2
Teleosts									
<i>Ichtyococcus ovatus</i>	2	1		2	1	1	2		9
<i>Myctophum punctatum</i>	2			1	1		2		6
<i>Gadiculus argenteus</i>			2		2		1		5
<i>Phycis phycis</i>			1		1				2
<i>Hoplosthetus mediterraneus</i>			1			1			2
<i>Callyonimus</i> sp.			1			1			2
unidentified	1	1	1	1		2	1	2	9

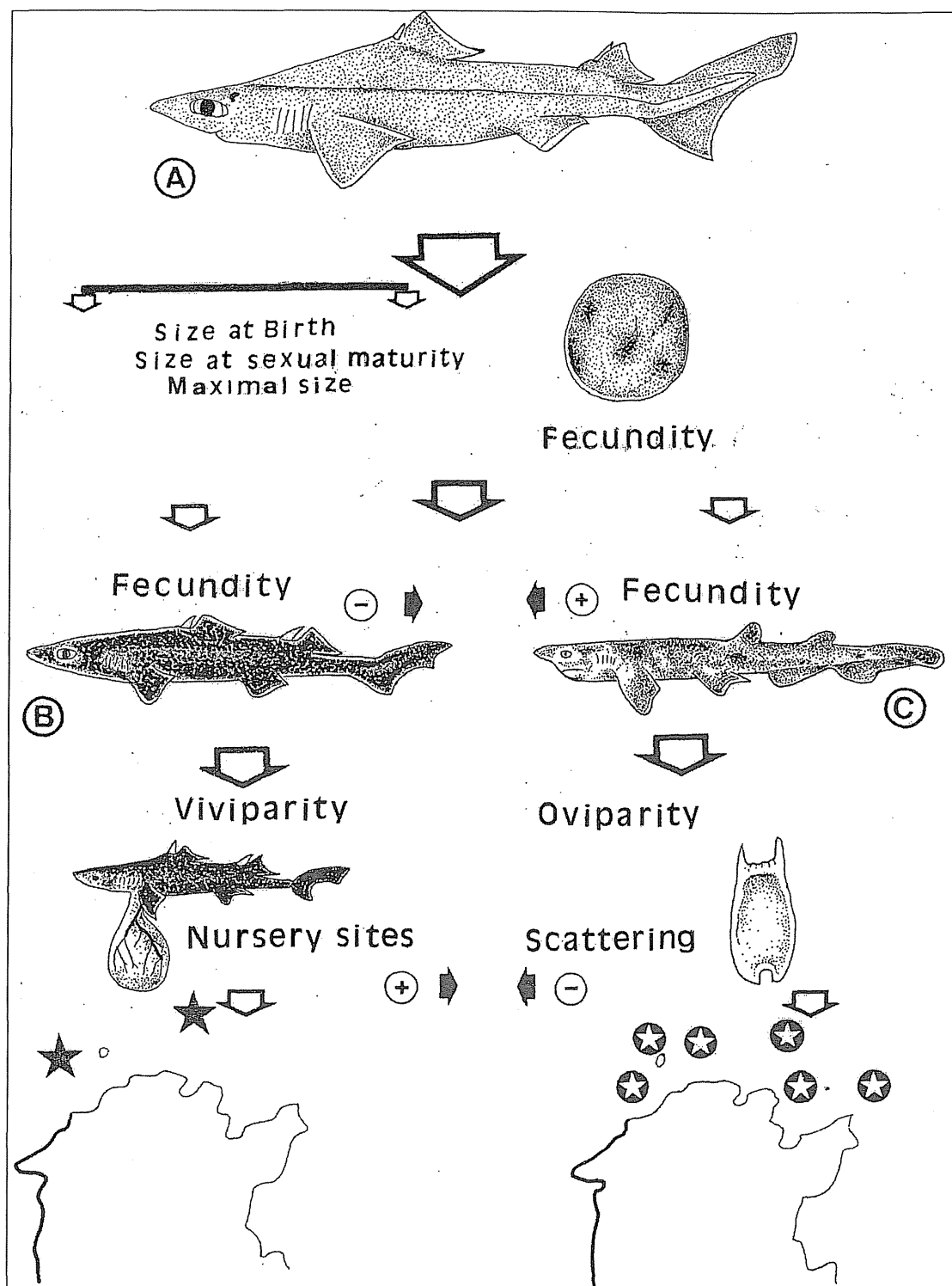
Wheeler (1969) reported Euphausiacea, crustaceans and bony fishes of the genus *Micromesistius* in stomachs contents of specimens from British waters. In Italian seas, according to Bini (1967), the species feeds on cephalopod molluscs and small decapod crustaceans. Capapé (1975) found some unidentifiable teleosts in stomach contents of some *E. spinax* caught off the Tunisian coast. Orsi Relini & Würtz (1977) analysed and compared stomach contents of the velvet belly and the blackmouth catshark from the Ligurian Sea. They wrote that "*E. spinax* feeds in the pelagic zone above all on large size preys; its food specially seems to be orientated towards nektonic cephalopods." McPherson (1980) noted that prey composition in *E. spinax* usually consists on fishes, cephalopods, Euphausiacea and crustacean decapods in the western Mediterranean. Kabasakal & Unsal (1999) examined stomach contents of five specimens caught in the north-eastern Aegean Sea, two of which were empty, while the others contained remains

of decapod crustaceans, cephalopods and teleosts.

Tab. 4: Comparisons of annual percent of occurrence (PO) between *Etmopterus spinax*, *Centrophorus granulosus* and *Galeus melastomus* for each category

Tab. 4: Primerjava števila polnih želodcev (PO; letni delež v %) globokomorskih vrst morskih psov *Etmopterus spinax*, *Centrophorus granulosus* in *Galeus melastomus* glede na starostno kategorijo.

Category	Non-adults		Adults		Average annual PO
Species	n	PO	n	PO	
<i>Etmopterus spinax</i>	90	82.5	30	83.5	83.0
<i>Centrophorus granulosus</i>	81	89.0	68	79.0	84.0
<i>Galeus melastomus</i>	276	80.4	166	79.6	80.0



**Fig. 2: Interspecific competition among (A) *Centrophorus granulosus*, (B) *Etmopterus spinax* and (C) *Galeus melastomus*, involving factors which increase (+) or reduce (-) the demographic pressure exerted by one species on another (partially redrawn from Capapé, 1989).**

**Sl. 2: Tekmovanje med vrstami (A) *Centrophorus granulosus*, (B) *Etmopterus spinax* in (C) *Galeus melastomus*, z dejavniki, ki povečujejo (+) ali zmanjšujejo (-) demografske pritiske, ki jih ustvarja ena vrsta na drugo (delno prirejeno po Capapé, 1989).**

The elasmobranch occurrence in stomach contents of some Tunisian velvet bellies had probably accidental significance: they could be ingested during trawling. On the other hand, they could be the result of a competition pressure for food items. Records of elasmobranchs as prey items are usually reported in diet of elasmobranch species (Bigelow & Schroeder, 1948; Stevens & Lyle, 1989; Waller & Baranes, 1994). Moreover, the record of *E. spinax* in stomach contents of our sample species probably suggests a case of cannibalism in elasmobranchs, nevertheless different of oophagy and/or adelphophagy described in other sharks (Springer, 1948; Gilmore, 1983; Gilmore et al., 1983).

During trawling surveys in deep areas off the Tunisian northern coast, two other deep-sea shark species, *G. melastomus* and *C. granulosus*, are concomitantly caught together with *E. spinax*. They probably inhabit the same or closed niches and competition for food between them could be inferred. For each shark, mean annual PO of the three sharks had high values, and were not significantly different ( $p > 0.01$ , Tab. 4). These high values suggest that they are active feeders, as well as that an important availability in food occurred in their respective habitats.

However, *E. spinax*, *C. granulosus* and *G. melastomus* feed on crustaceans, cephalopods and teleosts (Tab. 5), but crustaceans were mainly consumed by *E. spinax*, cephalopods by *G. melastomus* and teleosts by *C. granulosus*.

Moreover, of the 78 prey species numbered in stomach contents of *E. spinax*, *C. granulosus* and *G. melastomus*, only eight species were recorded in common. Intraspecific competition for food and consequently niche overlap for diet seem to be considerably reduced.

Referring to Golani & Galil (1991) and his own observations on the diet of the striped red mullet from the eastern central Adriatic, Dulčić (2002) wrote: "Food specialisation and dietary breadth are a result of evolutionary development of unique feeding behaviour, mor-

phology and mouth structure, which interact with the size, distribution and abundance characteristics of certain types of the available benthic fauna."

To explain the overlap of diet niches for the three deep-water sharks from the western Mediterranean, *G. melastomus*, *E. spinax* and *Dalatias licha*, McPherson (1980) used theoretical model based on mathematic parameters.

We have used only some biological parameters of the three sharks, which are summarized in Table 6 as size at birth, size at sexual maturity, maximal size, reproductive mode and fecundity. Their roles on interrelationships are generated as a model plotted in figure 2.

The gulper shark matures at a larger size and has a larger maximal size than its sympatric sharks and, consequently, it consumed larger preys than *E. spinax* and *G. melastomus* were able to do. A competition for food could be inferred between juvenile *C. granulosus* and adult *E. spinax* and *G. melastomus*, but this opinion needs confirmation: a spatial segregation occurs between sexes and categories of specimens in elasmobranch species (Waller & Baranes, 1994). Mouth width is smaller in *E. spinax* and *G. melanostomus* than in *C. granulosus*, and teeth counts and teeth shape are very different between the three species (Ledoux, 1970; Capapé & Ben Brahim, 1984). Moreover, the fecundity of the first species seems to be the lowest ever recorded in an elasmobranch species whatever the area (Sarà, 1968; Capapé, 1985; Mellinger, 1989; Golani & Pisanty, 2000; Guallart & Vicent, 2001). Its recruitment is poor, lesser than this of both *E. spinax* and *G. melastomus*. It expelled its foetuses, generally a single specimen per litter (Capapé, 1985; Guallart & Vicent, 2001) in nursery sites restricted at the level of the Bank of Esquerquis (northern Tunisia) as this was the case of *E. spinax* according to Capapé et al. (2001), but size at birth is very different for each species (Tab. 6) and competition pressure for food is reduced between them with regard to neonates and juveniles.

Tab. 5: Comparison of frequency indexes (FI) and number of species-preys (n) belonging to different prey items ingested by *Etmopterus spinax*, *Centrophorus granulosus* and *Galeus melastomus*.

Tab. 5: Primerjava frekvenčnih indeksov (FI) in števila vrst plena (n) posameznih skupin živali, ki so jih uplenile tri vrste morskih psov *Etmopterus spinax*, *Centrophorus granulosus* in *Galeus melastomus*.

Prey item	Crustaceans		Cephalopods		Teleosts		Other groups		Total
Species	FI	n	FI	n	FI	n	FI	n	n
<i>Etmopterus spinax</i>	0.55	7	0.21	3	0.33	6	0.10	3	19
<i>Centrophorus granulosus</i>	0.21	6	0.13	3	0.74	11	0.09	3	23
<i>Galeus melastomus</i>	0.44	11	0.44	5	0.53	13	0.08	7	36

**Tab. 6: Biometric measurements and reproductive data for *Etmopterus spinax*, *Centrophorus granulosus* and *Galeus melastomus*.**

**Tab. 6: Biometrični in razmnoževalni podatki za tri vrste morskih psov *Etmopterus spinax*, *Centrophorus granulosus* in *Galeus melastomus*.**

Species	Size at first maturity (mm)	Maximal size (mm)	Reproductive mode	Reproductive cycle period (months)	Fecundity	Authors
<i>Etmopterus spinax</i>	350-380	460	viviparous	24	5-17 / 2 years	Capapé <i>et al.</i> (2001)
<i>Centrophorus granulosus</i>	800-900	960-1280	viviparous	24	1 / 2 years	Capapé (1985)
<i>Galeus melastomus</i>	420	550-560	oviparous	?	15-25 / one year	Capapé & Zaouali (1977)

On the other hand, size at sexual maturity and maximal size do not show important differences between *E. spinax* and *G. melastomus* (Tab. 6). Moreover, the first is a viviparous species and the second an oviparous one. The deposition sites of egg capsules of the blackmouth catshark are widely distributed throughout the waters off northern Tunisia as well as scyliorhinid species from other marine areas (Capapé, 1977; Able & Flescher, 1991; Capapé *et al.*, 1991). Consequently, the discovery of egg-cases in *E. spinax* stomach contents could not affect the blackmouth cat shark populations. Barrul & Mate (2001) reported records of yolks sacks embryos of the small spotted catshark *Scyliorhinus canicula* in stomach contents of the angular roughshark *Oxynotus centrina*. They gave similar opinion as Cox & Koob (1993) who reported that predation of shark egg-case by marine animals is rather rare. However, a competition for food could be inferred between adults of *E. spinax* and *G. melastomus*. Nevertheless, the preference

of *E. spinax* for crustaceans and the cephalopod preference of *G. melastomus* considerably reduce this inter-specific competition between the adults of both species in the area. These observations allow to state that the three deep water sharks are able to live and reproduce off northern Tunisia.

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## UČINKI REPRODUKCIJSKIH DEJAVNIKOV NA MEDSEBOJNE ODNOSI MED TREMI VRSTAMI GLOBOKOMORSKIH PSOVI V OBALNIH VODAH TUNIZIJE

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#### POVZETEK

V obalnih vodah Tunizije se pojavljajo tri globokomorske vrste morskih psov: *Galeus melastomus* (Rafinesque, 1810), *Centrophorus granulosus* (Schneider, 1801) in *Etmopterus spinax* (Linnaeus, 1758), ki vsi naseljujejo podobne biotope. Med vrstami tu in tam poteka tekmovanje za hrano, pa čeprav je v teh vodah ravno ne manjka. Sicer pa je



med njimi zaznati različne morfološke značilnosti, kot na primer velikost, doseženo ob njihovi spolni zrelosti, maksimalna dolžina, plodnost in način razmnoževanja, živorodnost in jajcerodnost. In prav te značilnosti v veliki meri zmanjšujejo tekmovalnost teh treh vrst za hrano in dovoljujejo, da ti simpatrični globokomorski psi živijo in se razmnožujejo v tuniških obalnih vodah.

**Ključne besede:** globokomorski psi, *Etmopterus spinax*, *Galeus melastomus*, *Centrophorus granulosus*, sestava plena, biološki dejavniki, medsebojni odnosi, severna Tunizija, Sredozemlje

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## STATUS OF SHARKS IN THE MEDITERRANEAN

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### ABSTRACT

*In the Mediterranean, 47 shark species have been recorded so far. Some of these species are commercially important and have been exploited over the ages as target species or bycatch, while others are rare or very rare, and therefore have not been recorded on a regular basis. Due to the negative impact of irresponsible fisheries on sharks, a decline of some shark populations has been observed. The aim of this paper is to present the status of sharks in the Mediterranean and to propose some measures for their conservation and better management of their exploitation.*

**Key words:** sharks, status, fisheries, conservation, Mediterranean

## STATO DEGLI SQUALI NEL MEDITERRANEO

### SINTESI

*Quarantasette specie di squali sono state identificate nel mare Mediterraneo fino ad oggi. Alcune di esse hanno un alto valore commerciale e nel corso della storia sono state sfruttate come specie bersaglio o cacciate, mentre altre sono rare o molto rare e vengono avvistate solo occasionalmente. L'autore segnala il declino di alcune popolazioni di squali come conseguenza dell'impatto negativo di una pesca irresponsabile degli squali. Scopo dell'articolo è quello di fornire una corta descrizione dello stato degli squali nel mare Mediterraneo e di proporre alcune misure di conservazione e di migliore gestione del loro utilizzo.*

**Parole chiave:** squali, stato, pesca, conservazione, mare Mediterraneo

## INTRODUCTION

Ecologists classify sharks as strong "K selected species" due to their life history characteristics, such as slow growth rates, relatively late sexual maturation, long reproductive cycles, low fecundity potential and long life spans.

Many shark species, including commercially important species, are extremely slow growing. For instance, piked dogfish, *Squalus acanthias*, which is one of the most important commercial species in the Mediterranean, has been estimated to reach maturity at about 25 years (Jones & Geen, 1977). Hence, the sandbar shark, *Carcharhinus plumbeus*, also one of the commercially most important Mediterranean species, has been estimated to reach maturity from 15-16 years (Sminkey & Musick, 1995) to about 30 years (Casey & Natanson, 1992).

The reproductive cycle, which means how often the sharks reproduce, usually lasts for one or two years in most shark species, although longer cycles of three and four years have been also proposed for some species which, however, still need to be investigated more thoroughly. The gestation period, which is the time of embryonic development from fertilization to birth, also lasts for usually one or two years. For some species, such as the basking shark *Cetorhinus maximus*, it has been proposed that the gestation period lasts for 3.5 years (Compagno, 1984).

Sharks have low fecundity potential that is characterized by small number of young per litter, which usually ranges from two to twelve. Most of the carcharhinid sharks usually produce less than a dozen young per litter, with an exception of the blue shark, *Prionace glauca*, which produces over 30 pups, have often been reported (Castro *et al.*, 1999).

Some sharks have very long life span, e.g. tope shark, *Galeorhinus galeus*, which can live as long as 60-70 years (Vannuccini, 1999). Although the reproductive life span of many shark species still needs to be investigated comprehensively due to the long time that has to elapse before maturation and long reproductive cycles, it appears that a given female may only produce a few offspring in its lifetime (Sminkey & Musick, 1995), which makes the shark populations particularly vulnerable to overfishing. As there is no evidence of any compensatory mechanisms by female sharks that will increase brood size or decrease the length of ovarian and gestation cycles in response to overfishing, it is presumed that it is highly unlikely that those mechanisms can be evolved rapidly enough to compensate for the increase in mortality (Castro *et al.*, 1999).

The described life history characteristics, combined by integrated effects of mainly unmanaged and irresponsible fishing, pollution and habitat destruction, are causing changes in abundance, size structure and bio-

logical features of shark populations, which in the extreme could lead to extinction of some species in the Mediterranean. Hence, there are also indirect impacts on ecosystem due to changes in species prey-predator interactions that may lead to species replacement.

Rapid growth of shark fisheries in the early 1980s in the Mediterranean, as well as in the entire world, caused previously released or discarded sharks to be retained as bycatch and brought on board to be finned. Many shark species, which previously had no commercial value, became target species or important bycatch. From the facts that Mediterranean countries Italy and France are the major consuming countries of the shark meat, while Spain is the world's largest exporter of this meat (Vannuccini, 1999), it is obvious why public concern regarding the shark status in the Mediterranean is rising.

## MATERIAL AND METHODS

Data presented in this paper were collected from scientific and popular literature, FAO fisheries statistics and the "Report of the meeting of experts for the elaboration of an action plan for the conservation of Mediterranean species of cartilaginous fish", which is a summary of the meeting held in Rome on 10-12 October 2002. All common and scientific names of sharks used in this paper follow Anonymus (2002).

## RESULTS AND DISCUSSION

In the Mediterranean, 47 shark species (14 families) (Anonymus, 2002) have been recorded so far (Tab. 1). Some are common species and therefore of commercial importance as target species or bycatch, while some are rare or very rare and, therefore, not recorded on a regular basis. Currently, sharks are exploited by both commercial and recreational fisheries throughout the entire Mediterranean. Consequently, sharks are harvested by different fishing gear which ranges from large commercial gear (bottom and pelagic trawls, purse seines, floating longlines, driftnets...), small scale (artisanal) gear (bottom longlines, gillnets, trammel nets...) to recreational gear (trolling lines, hand lines, hooks...).

In IUCN's Red List of Mediterranean Sharks, one species has been characterized as endangered, 5 species are considered vulnerable, 16 species are in the category Lower risk (near threatened), while two species appear in the category Data deficient. Nevertheless, such list is based on currently existing and official assessments, while new preliminary reports show that overall situation is much worse.

It has to be pointed out that all assessments of shark species are mostly based on limited data due to the lack of biological and fisheries facts. Most fishery and ichthyological studies were concentrated on teleosts rather

than sharks, as those were of low economical value and were difficult to sample. Therefore shark biology has been neglected in the past. Although the situation has changed in the last two decades owing to an increase in the shark's economical value and rising of the general concern regarding their status, such studies are still rather slow moving and deficient. Regarding shark fishery, most of the countries do not report their data concerning shark landings, especially by species. There are many different reasons for such behaviour (which would not be elaborated in this paper), which leads to the conclusion that there will be no significant changes in the future. Consequently, there are no suitable models to assess shark populations. Moreover, most of the models are based on bony fishes, whose life history characteristics are quite different to those of the sharks, which mean that even if biological and fishery data would exist, results from such models would be questionable.

Knowing such limitations and with present data it is a great problem to determine the actual sharks' status. Nevertheless, based on known life history characteristics and available data, the following has been established as far as the status of Mediterranean sharks is concerned:

#### Family Hexanchidae

Both species from this family, the sharpnose seven-gill shark and bluntnose sixgill shark, are deep-water species and their landings in the Mediterranean have not been reported. However, although they are not target species, they have been caught as bycatch by trawls, bottom longlines and gillnets. It appears that their habitat, due to its depth where low number of fishing gear operates, is relatively protected, but data for the evaluation of bycatch impact are still insufficient. Although they belong to non-exploited species, their life history characteristics along with the fact that juveniles comes into very shallow waters (Castro *et al.*, 1999), where they are exposed to much larger number of fishing gear and therefore higher fishing pressure, makes them particularly vulnerable to overfishing. *H. griseus* is listed in IUCN/SSG Red List.

#### Family Centrophoridae

This family has been presented in the Mediterranean by 4 species: *Centrophorus granulosus*, *C. squamosus*, *C. uyato* and *Deania calcea*. As these species are of no interest to fisheries, therefore they belong to non-exploited species. Nevertheless, those deep-sea species are being exploited, as bycatch, by unmanaged fisheries, so studies are required to determine their poorly known life history characteristics and other parameters necessary for better management. According to current knowledge it can be said that their life history charac-

teristic makes them highly vulnerable to overexploitation and population depletion. *C. granulosus* is listed in IUCN/SSG Red List.

#### Family Dalatiidae

Regarding the number of its' representatives, *Centroscymnus coelolepis*, *C. crepidater*, *Dalatias licha*, *Etmopterus spinax*, *Oxynotus centrina*, *Scymnodon ringens* and *Somniosus rostratus*, the family Dalatiidae occupies a remarkable place among the Mediterranean sharks. None of these species belongs to target species, but they are often caught as bycatch of different fishing gears such as trawls, longlines, gillnets and trammel nets and even handlines. Similar to previously described family, life history characteristics are still poorly known, but based on the reported decline of *D. licha* in other areas and problems in determining of proper MSY (da Silva, 1983, 1987), this family deserves much greater attention and better management. *D. licha* is listed in IUCN/SSG Red List.

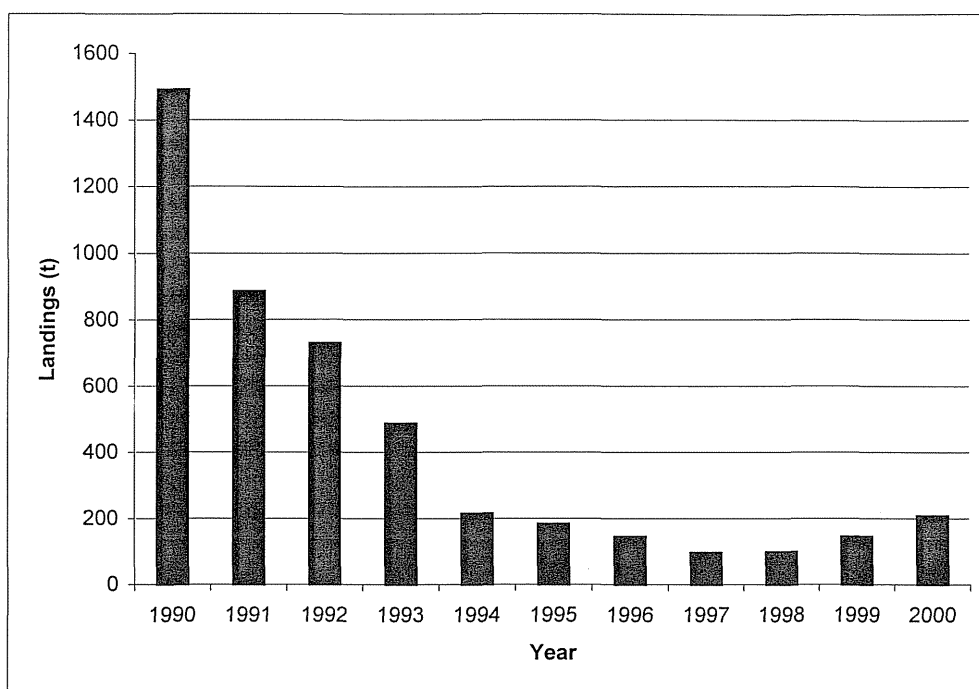
#### Family Echinorhinidae

*Echinorhinus brucus*, a deep-sea shark species, is the only representative of this family in the Mediterranean. This species is currently very rare in the Mediterranean, even locally extinct. As very little is known about its reproductive processes, it is suggested that its rarity and local disappearance indicate that this species may be very long-lived and slow-reproducing, and that bycatches of this species may be sufficient to prevent replacement of locally exploited populations (Castro *et al.*, 1999).

#### Family Squalidae

*Squalus acanthias* and *S. blainvillei* are the representatives of Squalidae in the Mediterranean, of which *S. acanthias* is probably the most abundant shark and the only species whose commercial importance can be compared to commercially important bony fishes (Compagno, 1984). Moreover, this species is one of the rare shark species whose landings have been officially reported by several Mediterranean countries. Hence, landings of *S. acanthias* in the Mediterranean show a dramatic decrease (Fig. 1) from 1490 tonnes reported in 1990 to only 95 tonnes in 1997, while more recent data from 2000 have shown an increase to 206 tonnes (FAO, 2002). Mostly, it is caught by bottom trawls, but even by gillnets and longlines. This shark is one of the most studied species, as it is one of the relatively few sharks that can be kept in captivity for a few years (Castro *et al.*, 1999). Accordingly, the vulnerability to overfishing of this species has been known for a long time, so in many countries all over the world its stocks are already





**Fig. 1:** *Squalus acanthias* landings for the Mediterranean area (FAO area 37) (FAO, 2002).

**Sl. 1:** Ulov morskega psa trneža *Squalus acanthias* v Sredozemskem morju v tonah (FAO predel 37) (FAO, 2002).

considered as overexploited by scientists (Vannuccini, 1999). Although some Mediterranean countries have reported its landings, the biggest fishing countries, such as Italy, have not reported any landings at all, while France and Spain have reported only on minor quantities, and even this only occasionally. Also, it still needs to be determined whether the reported landings concern *S. acanthias* only, or are mixed with catches of *S. blainvillei*. Some countries have reported on landings of this family as of a group (Dogfish sharks). These landings also showed decline as it can be seen in a case of Tunisia (from 1183 tonnes in 1992 to 19 tonnes in 1996) or Croatia (from 535 tonnes in 1993 to 50 tonnes in 2000). Other landings show smaller fluctuations, or have been reported sporadically. Therefore, knowing life history characteristics such deficient landing data suggest that appropriate management programs should be established for each country in order to prevent decline of these species in the entire Mediterranean. *S. acanthias* is listed in IUCN/SSG Red List.

#### Family Carcharhinidae

This is the largest family of sharks in the Mediterranean, represented by 10 small to large, bottom to pelagic species. It is also commercially most important family, as many of these species are used for food, fins, leather, etc. Some species are wide-ranging or cosmopolitan (Castro *et al.*, 1999). Mostly they are caught by

longlines, trawls and gillnets, but even with handlines, particularly in recreational fisheries.

Most of these species are slow growing species with late maturity. Thus, the smallest mature specimens of *Carcharhinus altimus* were a 213 cm TL male and 221 cm TL female (Springer, 1960). *C. brachyurus* sexual maturity age was calculated at 13-19 years for males and 19-20 years for females (Walter & Ebert, 1991). *C. brevipinna* (listed in IUCN/SSG Red List) males mature at 130 cm TL or 4-5 years, while females mature at 150-155 cm TL or 7-8 years (Branstetter, 1987). According to Bonfil *et al.* (1993), *C. falciformis* (listed in IUCN/SSG Red List) males mature at 225 cm TL (about 10 years) and females at 232-245 cm TL (more than 12 years old). Males of *C. leucas* (listed in IUCN/SSG Red List) mature at 210-220 cm TL or 14-15 years of age, while females mature at least at 225 cm TL, which corresponds to more than 18 years of age (Branstetter & Stiles, 1987). Wintner & Cliff (1996) determined the maturity age for *C. limbatus* (listed in IUCN/SSG Red List) females at 7 years, and 6 years for males. Seki *et al.* (1998) gave the size at maturity of *C. longimanus* (listed in IUCN/SSG Red List) for both males and females as 175-189 cm TL, corresponding to an age of 4-5 years. *C. obscurus* (listed in IUCN/SSG Red List) mature very late, males at about 279 cm TL, corresponding to 19 years of age, and females at about 284 cm TL, corresponding to 21 years of age (Natanson *et al.*, 1995). *C. plumbeus* (listed in IUCN/SSG Red List) is also a very slow growing species, its maturity

age ranging for both sexes from 15-16 years (Sminkey & Musick, 1995) to 29-30 years (Casey & Natanson, 1992). Similar situation has been observed in the case of *Prionace glauca* (listed in IUCN/SSG Red List), whose maturity has indeed not been accurately determined as yet, but based on different studies it ranges from 4 to 7 years (Cailliet *et al.*, 1983; Nakano, 1994).

Minor and sporadic landings of these species in the Mediterranean have been reported only for blue shark from France and Portugal. Indications (severe declines) from other areas have shown that these species are highly vulnerable to overfishing. Among other "usual" difficulties, the ever-increasing problem as far as this shark family is concerned is the practice of finning (the removal and retention of shark fins, while the rest of the carcass has been discarded at sea), as this fishery activity particularly threatens this family. Finning obstruct the collection of the species-specific scientific data that are essential for monitoring catches and landings and implementing sustainable shark fisheries management. Moreover, there are often no accurate data on the quantities of shark fins taken, landed or exported due to the lack of classification in fisheries statistics and/or enforcement of reporting requests, so the limited reported shark landing data represent primarily the whole sharks. Owing to the fact that many of these sharks have become rare or even locally extinct and that many among them are cosmopolitan and tend to migrate throughout the entire Mediterranean, it is clear that these sharks are particularly vulnerable to overfishing. Therefore, it is essential to establish a proper management plan, based on accurate statistics, followed by wide biological and ecological studies, not only for each country, but also for the entire Mediterranean area.

#### Family Sphyrnidae

In the Mediterranean, hammerhead sharks are represented by three large species: *Sphyrna lewini*, *S. mokarran* and *S. zygaena*. They are caught mainly by longlines and gillnets, especially as bycatch in tuna and swordfish fishery. This family is also subject to finning practice in unidentified quantities. Landings of these sharks have not been reported in the Mediterranean either by species or by group. As large sharks, with life history characteristics similar to Carcharhinidae, these sharks are known for their vulnerability to overfishing all over the world. In *Draft action plan for the conservation of cartilaginous fishes (Chondrichthyans) in the Mediterranean Sea* all species were noted as data deficient with inadequate information and thus with urgent need for their assessment of extinction risk. Therefore, accurate statistics of landings, whether of whole or finned sharks, have to be established in order to provide sufficient data for a proper management plan, especially as it is known that all three species are listed in IUCN/SSG Red List.

#### Family Scyliorhinidae

This family of relatively small catsharks is represented by three species in the Mediterranean: *Galeus melastomus*, *Scyliorhinus canicula* and *S. stellaris*. They are not target species, but are as bottom sharks often caught by trawls as bycatch. There is no fishery statistic by species, but as a group *Scyliorhinus* spp. landings have been reported from Tunisia and, more recently, from Spain. Landings in the Mediterranean have highly increased from 36 tonnes in 1996 to 457 tonnes in 2000 on the account of some recent reports from Spain. Obviously, these species are caught by trawls from many countries, but with such deficient landing data it is hard to give a proper assessment. Nevertheless, these sharks should be included in fishery statistics, which will provide possibilities for future management.

#### Family Triakidae

In the Mediterranean, this family is represented by four species: *Galeorhinus galeus*, *Mustelus asterias*, *M. mustelus* and *M. punctulatus*. All four species have been intensively caught as bycatch in trawl, longline and gillnet fishery. Although these sharks are generally not classified as target species, they are treated as (locally) economically important in some areas. As a group, *Mustelus* spp. landings have been reported by many Mediterranean countries. Statistics showed severe decline from overall 13,437 tonnes in 1994 to 2980 tonnes in 1997. Landings of smooth-hound sharks in the Mediterranean amounted to as much as 67.7% of all world landings. Therefore, this family is one of the most commercially important shark families in the Mediterranean. However, some important fishing countries, such as Spain and France, seem not to have landed, according to the statistics, any smooth-hound shark at all in the area or have recorded only small quantities (Vannuccini, 1999). Knowing that the intensive fishery of *G. galeus* off the western coast of North America in the late 1930s and 1940s collapsed by 1950 due to overexploitation, and stocks have not recovered ever since (Castro *et al.*, 1999), it is feared that a similar situation could occur in the Mediterranean, particularly as with the exception of *M. punctulatus* all species have been listed in IUCN/SSG Red List (of which *G. galeus* is listed as globally vulnerable). Thus, a proper management plan is essential for the future preservation of these species.

#### Family Odontaspidae

Sand tiger sharks are in the Mediterranean represented by two species: *Eugomphodus taurus* and *Odontaspis ferox*. Landings of these species have not been reported by statistic data of any Mediterranean country. They are caught as bycatch by trawls, longlines

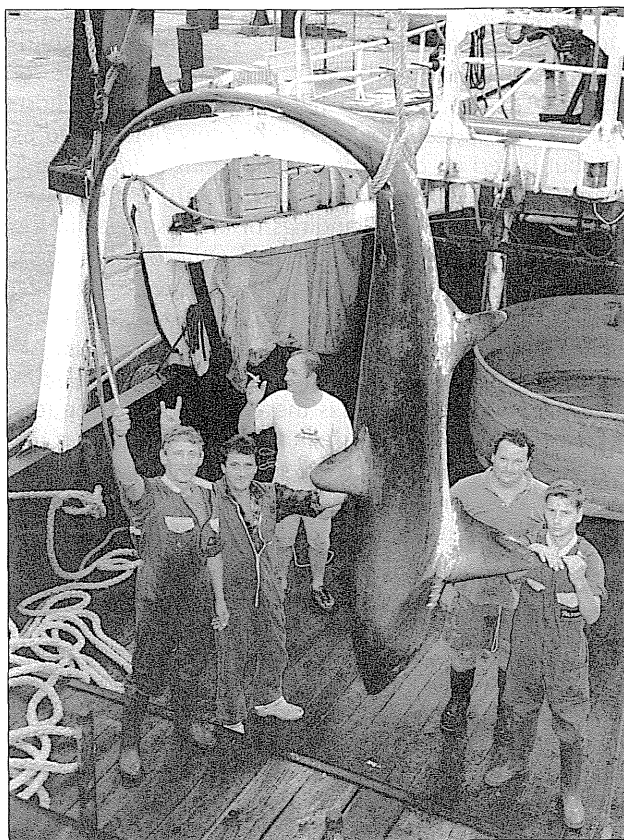
and gillnets. *E. taurus* is known to be a very vulnerable species, as it congregates in large numbers, probably during mating, at particular spots at specific times of year. These spots are known to commercial fishermen who can catch very large numbers of sand tigers with minimal effort, but with serious effect on the population (Castro *et al.*, 1999). Severe population declines of this species throughout the world started in the 1960s and 1970s, and *E. taurus* was one of the first sharks to receive fully protected status anywhere in the world (Pollard, 1996). In many areas of the Mediterranean it is currently found rarely or very rarely. Its life history characteristics, especially very limited fecundity (two young per brood) probably contributes to its vulnerability (Castro *et al.*, 1999). IUCN/SSG Red list has listed it as critically endangered. Hence, in *Draft action plan for the conservation of cartilaginous fishes (Chondrichthyan) in the Mediterranean Sea*, both species have been prioritised and recommended for urgent provision of legal protection status for the endangered species identified at the regional and national levels. Therefore, it is evident that both species need a proper management plan for their protection as soon as possible.

#### Family Alopiidae

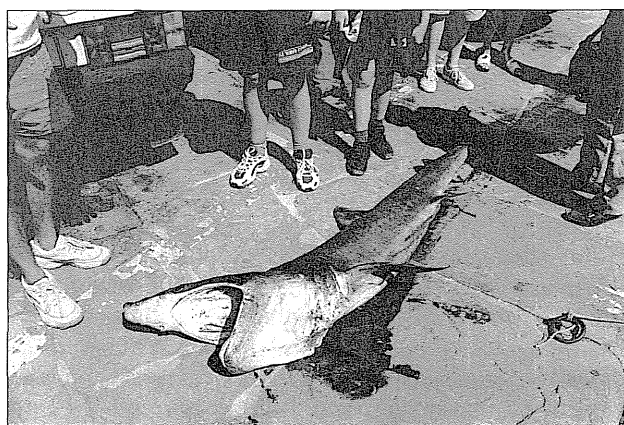
Two large oceanic species, *Alopias superciliosus* and *A. vulpinus*, represent tresher sharks in the Mediterranean. Slow growth and limited reproductive potential characterize both species. Official landings in the Mediterranean have been reported only recently for *A. vulpinus* by France. Tresher sharks are caught mainly by fishing gear used in tuna, swordfish and small pelagic fishery (Fig. 2). Both species have suffered severe declines in catches throughout the world, and continued to decline in spite of numerous regulations restricting fishing (Hanan *et al.*, 1993). Consequently, in order to avoid such situation in the Mediterranean area, proper management programs for sustainable fisheries should be developed for these species. *A. vulpinus* is also listed in IUCN/SSG Red List.

#### Family Cetorhinidae

The only member of this family, *Cetorhinus maximus*, is also the largest fish in the Mediterranean (Fig. 3). Landings of basking shark in the Mediterranean have been reported only recently and by Spain only (FAO, 2002). As it is known that lately only the landings in the Adriatic, by accidental captures, can be several tonnes per year (Zuffa *et al.*, 2001; Soldo & Jardas, 2002a, b), it is obvious that the official statistics for the Mediterranean area (2-6 tonnes per year) is far from accurate. Basking sharks are not target species in the Mediterranean but are accidentally caught by numerous fishing



**Fig. 2: Tresher sharks (*Alopias vulpinus*) are relatively often caught in the northern Adriatic. (Photo: B. Šuligoj)**  
**Sl. 2: Morske lisice (*Alopias vulpinus*) so razmeroma pogost plen ribičev v severnem Jadranu. (Foto: B. Šuligoj)**



**Fig. 3: Basking sharks are accidentally caught by numerous fishing gears. (Photo: B. Šuligoj)**  
**Sl. 3: Morski psi orjaki se naključno zapletejo v različne vrste ribiških mrež. (Foto: B. Šuligoj)**

gears. Thus, they are evidently vulnerable to overfishing, which has been recognized in the Mediterranean where they earned protective status by the Barcelona Convention. As most contracting parties have not yet implemented such status in their fishery legislative, there is still much work to be done on protection of this species, which is also listed in IUCN/SSG Red List.

### Family Lamnidae

Mackerel sharks are in the Mediterranean represented by three large cosmopolitan sharks: *Carcharodon carcharias*, *Isurus oxyrinchus* and *Lamna nasus*. Official statistics show that the only landings in the Mediterranean have been reported by Portugal for *I. oxyrinchus* in 2000 (1 tonne) and in 1996 by Malta 1 tonne for *L. nasus* (FAO, 2002). These species are not target species in the Mediterranean area, but they are caught mainly as bycatch by longlines, driftnets and other fishing gear used in tuna, small pelagic fish and sword fisheries. Of these sharks, the largest and apex predator is the great white shark (listed in IUCN/SSG Red List). Although little is known of its reproduction, some studies show that its populations may be small and highly localized and very vulnerable to overexploitation (Strong *et al.*, 1992). In same Mediterranean areas, e.g. Eastern Adriatic where it used to be a common species, it has not been reported for at least 30 years (Soldo & Jardas, 2002b). The decline of records has also been observed in other areas, so the Barcelona Convention contracting parties have proclaimed this shark a protected species in the Mediterranean area (it is also listed in IUCN/SSG Red List). However, as in case of *C. maximus*, this still has to be incorporated in these countries' legislation.

Intensive fisheries of cosmopolitan species that depleted the stocks in areas out of Mediterranean have also a strong impact on the occurrence of these species in the Mediterranean. Studies showed that *I. oxyrinchus* and *L. nasus* have been common species in the Eastern Adriatic, but in the last 30 years there have been only few (porbeagle), or no records at all (shortfin mako) of these species in the area, although no fisheries of these two species have been reported in this area (Soldo & Jardas, 2002a). Even though there is a general lack of information regarding these species in the Mediterranean and that we are well acquainted with their life history characteristic and their vulnerability to overfishing (both species have been listed in IUCN/SSG Red List), it is obvious that they deserves rigorous attention as their populations are under serious threats of unmanaged and irresponsible fishing. Thus, a proper management programs should be developed and, upon accurate assessment, some local protection probably established.

### Family Squatinidae

In the Mediterranean Sea, the flattened angel sharks are represented by three species: *Squatina aculeata*, *S. oculata* and *S. squatina*. They are not target species but caught as bycatch by trawls, gillnets and longlines. Landings of *S. squatina* have been reported by Tunisia (10-53 tonnes in the period 1991-2000), while several other countries have reported only on landings of these sharks as a group. Landings of Squatinidae show increase from 13 tonnes in 1992 to 171 tonnes in 1998. Apparently, or at least on the basis of this deficient data, a market for these sharks is growing. Thus a proper management plans for sustainable fisheries of these species should be developed, especially if it is known that some of these species (*S. squatina*) are already listed in IUCN/SSG Red List.

#### Tab. 1: Checklist of Mediterranean sharks.

#### Tab. 1: Seznam sredozemskih morskih psov.

### Hexanchiformes

#### Hexanchidae

*Heptranchias perlo* (Bonnaterre, 1788), Sharpnose sevengill shark

*Hexanchus griseus* (Bonnaterre, 1788), Bluntnose sixgill shark

### Squaliformes

#### Centrophoridae

*Centrophorus granulosus* (Schneider, 1801), Gulper shark

*Centrophorus squamosus* (Bonnaterre, 1788), Gulper shark

*Centrophorus uyato* (Rafinesque, 1810), Little gulper shark

*Deania calcea* (Lowe, 1839), Birdbeak dogfish

#### Dalatidae

*Centroscymnus coelolepis* (Bocage & Capello, 1864), Portuguese dogfish

*Centroscymnus crepidater* (Bocage & Capello, 1864), Longnose velvet dogfish

*Dalatias licha* (Bonnaterre, 1788), Kitefin shark

*Etmopterus spinax* (Linnaeus, 1758), Velvet-belly shark

*Oxynotus centrina* (Linnaeus, 1758), Angular rough shark

*Scymnodon ringens* (Bocage & Capello, 1864), Knifetooth shark

*Somniosus rostratus* (Risso, 1826), Little sleeper shark

#### Echinorhinidae

*Echinorhinus brucus* (Bonnaterre, 1788), Bramble shark

#### Squalidae

*Squalus acanthias* (Linnaeus, 1758), Piked dogfish

*Squalus blainvillei* (Risso, 1826), Longnose spurdog

### Carcharhiniformes

#### Carcharhinidae

*Carcharhinus altimus* (Springer, 1950), Bignose shark

*Carcharhinus brachyurus* (Gunther, 1870), Copper shark  
*Carcharhinus brevipinna* (Muller & Henle, 1841), Spinner shark  
*Carcharhinus falciformis* (Bibron, 1841), Silky shark  
*Carcharhinus leucas* (Valenciennes, 1841), Bull shark  
*Carcharhinus limbatus* (Valenciennes, 1841), Blacktip shark  
*Carcharhinus longimanus* (Poey, 1861), Oceanic white tip shark  
*Carcharhinus obscurus* (LeSueur, 1818), Dusky shark  
*Carcharhinus plumbeus* (Nardo, 1827), Sandbar shark  
*Prionace glauca* (Linnaeus, 1758), Blue shark  
Sphyrnidae  
*Sphyrna lewini* (Griffith & Smith, 1834), Scalloped hammerhead  
*Sphyrna mokarran* (Ruppell, 1835), Great hammerhead  
*Sphyrna zygaena* (Linnaeus, 1758), Smooth hammerhead  
Scyliorhinidae  
*Galeus melastomus* (Rafinesque, 1810), Blackmouth catshark  
*Scyliorhinus canicula* (Linnaeus, 1758), Smallspotted catshark  
*Scyliorhinus stellaris* (Linnaeus, 1758), Nursehound  
Triakidae  
*Galeorhinus galeus* (Linnaeus, 1758), Tope shark  
*Mustelus asterias* (Cloquet, 1821), Starry smoothhound  
*Mustelus mustelus* (Linnaeus, 1758), Smoothhound  
*Mustelus punctulatus* (Risso, 1826), Blackspotted smoothhound  
**Lamniformes**  
Odontaspidae  
*Eugomphodus taurus* (Rafinesque, 1810), Sand tiger shark  
*Odontaspis ferox* (Risso, 1810), Smalltooth sand tiger  
Alopiidae  
*Alopias superciliosus* (Lowe, 1840), Bigeye thresher  
*Alopias vulpinus* (Bonnaterre, 1788), Thresher shark  
Cetorhinidae  
*Cetorhinus maximus* (Gunnerus, 1765), Basking shark  
Lamnidae  
*Carcharodon carcharias* (Linnaeus, 1758), Great white shark  
*Isurus oxyrinchus* (Rafinesque, 1810), Shortfin mako  
*Lamna nasus* (Bonnaterre, 1788), Porbeagle  
**Squatiniiformes**  
Squatinae  
*Squatina aculeata* (Cuvier, 1829), Sawback  
*Squatina oculata* (Bonaparte, 1840), Smoothback angelshark  
*Squatina squatina* (Linnaeus, 1758), Angelshark

## CONCLUSIONS

From previous facts it is obvious that there is a general lack of data on all sharks in the Mediterranean. It is most possible that some shark populations have suffered severe declines, due to unmanaged and irresponsible fisheries. It can also be said that the need for management of shark fisheries in order to ensure their long-term conservation has still not been recognized in the Mediterranean area. Some attempts have indeed been made, such as the *Draft action plan for the conservation of cartilaginous fishes (Chondrichthyans) in the Mediterranean Sea*, but such actions are unfortunately merely an exception and very slow in progress, which makes the future of the shark populations very uncertain. As Mediterranean fisheries are a multi-species fishery, severe resistance and actual rejections concerning the implementation of shark managing programs are coming from fishermen, especially trawlers, as they are afraid of possible regulations, which could have a strong effect on their fishing gear, technique, seasons etc., i.e. their incomes. A suitable way would therefore perhaps be to concentrate first on large pelagic species, which are most vulnerable but caught as bycatch by fishing gear, whose selectivity and fishing technique can be regulated much easier than trawls. That would open much more space for the introduction of management programs for target sharks, which are mainly bottom species caught by trawls. Of course, such actions should go along with public awareness building regarding the conservation and protection of sharks by various educational programs.

Management programs should ensure precise fisheries statistics of catches and landings by species. Critical habitats, namely mating areas, spawning and nursery grounds should be identified. Hence, scientific studies on biology and ecology of sharks should be continued and some new developed at the same time. Fishing gear and techniques that reduce shark bycatch and/or make possible live release should be encouraged, while wasteful fishing practices as finning should be banned. By regularly reviewed status of sharks, threatened species should be legally protected by national and international legislation. As many sharks are cosmopolitan, migratory species, regional coordination would be required for all these actions.

Generally, all management programs should respect the principles of sustainability, precautionary principles and conservation measures as defined in the *FAO Code of Conduct for Responsible Fisheries* and in the *International Plan of Action for the Conservation and Management of Sharks*.

Such approach will, hopefully, ensure conservation of shark populations and biodiversity of marine ecosystem of the Mediterranean Sea.



## STATUS MORSKIH PSOVI V SREDOZEMSKEM MORJU

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## POVZETEK

Doslej je bilo v Sredozemskem morju ugotovljenih 47 vrst morskih psov. Nekatere izmed njih so gospodarsko pomembne, tako da jih že stoletja lovijo načrtno ali pa zgolj naključno, medtem ko so druge vrste redke ali celo zelo redke, kar pomeni, da njihovo pojavljanje ni bilo zabeleženo na običajni osnovi. Sicer pa je bilo zaradi negativnih vplivov neodgovornih ribiških flot na morske pse opaženo upadanje populacij nekaterih vrst. Namen pričujočega članka je predstaviti status morskih psov v Sredozemskem morju in predlagati nekaj ukrepov za njihovo ohranitev in boljše upravljanje njihovega izkoriščanja.

**Ključne besede:** morski psi, njihov status, ribiška industrija, ohranjanje vrst, Sredozemlje

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## SHARKS CAPTURED OFF PESCARA (ITALY, WESTERN ADRIATIC SEA)

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### ABSTRACT

*We present the results of a study of sharks captured in the waters off Pescara, Italy (Adriatic Sea), from May 2000 to March 2003. We recorded 144 sharks, representing at least 11 species: houndsharks (Mustelus sp. and maybe Leptocharias smithii, 29.86% of total captures), catsharks (Scyliorhinus canicula, S. stellaris and S. sp., 28.47%), Squalus acanthias (24.30%), Hexanchus griseus (5.55%), Prionace glauca (4.86%), Lamna nasus (2.77%), Cetorhinus maximus (2.08%), Alopias vulpinus (0.69%), Oxynotus centrina (0.69%) and Centrophorus sp. (0.69%). We also had the opportunity to gather information concerning some captures of P. glauca, A. vulpinus, Carcharodon carcharias and unidentified lamnid sharks that had occurred in previous years. In these waters, H. griseus appears to be relatively abundant and L. nasus is more common than previously believed; the paucity of captures of P. glauca may present cause for concern.*

**Key words:** sharks, fishery, Italy, Adriatic Sea, Mediterranean Sea

## GLI SQUALI CATTURATI NELLE ACQUE DI PESCARA (ITALIA, MARE ADRIATICO OCCIDENTALE)

### SINTESI

*Vengono presentati i risultati di uno studio degli squali pescati nelle acque di Pescara, Italia (Mare Adriatico), dal Maggio 2000 al Marzo 2003. Sono stati registrati 144 esemplari, riferibili ad almeno 11 specie: palombi (Mustelus sp. e forse Leptocharias smithii, 29.86% delle catture totali), gattucci (Scyliorhinus canicula, S. stellaris e S. sp., 28.47%), Squalus acanthias (24.30%), Hexanchus griseus (5.55%), Prionace glauca (4.86%), Lamna nasus (2.77%), Cetorhinus maximus (2.08%), Alopias vulpinus (0.69%), Oxynotus centrina (0.69%) e Centrophorus sp. (0.69%). E' stato inoltre possibile rilevare informazioni inerenti ad alcune catture di P. glauca, A. vulpinus, Carcharodon carcharias e lamnidi non identificati occorse in anni precedenti. In queste acque H. griseus appare relativamente frequente e L. nasus è più comune di quanto si ritenesse; è preoccupante l'esiguità di catture di P. glauca.*

**Parole chiave:** squali, pesca, Italia, Mare Adriatico, Mare Mediterraneo

## INTRODUCTION

The capture of sharks, mostly as by-catch, along the Italian coast has only rarely been the object of specific and long-term analysis (De Maddalena & Piscitelli, 2001). However, such studies are an important source of data that, correctly interpreted, allow us to significantly increase our knowledge of sharks inhabiting the Mediterranean Sea. Such an investigation permits us to gather fundamental information on occurrence, distribution, relative abundance and fisheries status of many shark species. For these reasons, a study of the sharks captured in the waters off Pescara, Abruzzi, Italy (Western Adriatic Sea), an area where shark fauna have previously been only infrequently and irregularly investigated, has been conducted over a three-year period.

## MATERIAL AND METHODS

This study commenced in May 2000 and is still in progress, the results presented herein are those obtained through March 2003. This program is among the various regional initiatives that began following the formation of the Mediterranean Shark Research Group (MSRG), of which both authors are members. This study has been conducted primarily through periodic examination of the fish brought to Pescara Fish Market and by maintaining contacts with the veterinary staff and the fishermen working with that organization. Through these contacts many specimens observed by the Fish Market staff were added to those that were personally examined by one of the authors (G. C.). Additionally, we actively solicited the collaboration and participation of sport fishermen in the study area. Whenever possible, the following data were collected for each specimen: species, size, sex, location and date of capture. In some cases, it was also possible to collect photographic or filmed evidence of the specimens. Other additional data, such as weight of the specimen and distance from the coast, were only rarely collected.

The size of each shark was recorded as total length (TOT) measured as a straight line extending from the tip of the snout to the tip of the upper lobe of caudal fin, with the caudal fin in the depressed position, which is also the maximum length (Compagno, 1984). The classification we followed is that of Compagno (1984).

## RESULTS

During the study period we recorded 144 sharks, representing at least 11 species, 9 families and 4 orders. These were: order Hexanchiformes: bluntnose sixgill

shark, *Hexanchus griseus* (n=8) (family Hexanchidae); order Squaliformes: gulper shark, *Centrophorus sp.* (n=1), piked dogfish, *Squalus acanthias* (n=35) (family Squalidae), angular roughshark, *Oxynotus centrina* (n=1) (family Oxynotidae); order Lamniformes: common thresher shark, *Alopias vulpinus* (n=1) (family Alopiidae), basking shark, *Cetorhinus maximus* (n=3) (family Cetorhinidae), porbeagle, *Lamna nasus* (n=4) (family Lamnidae); order Carcharhiniformes: small-spotted catshark *Scyliorhinus canicula* (n=20), nursehound, *Scyliorhinus stellaris* (n=1) (family Scyliorhinidae), barbeled houndshark, *Leptocharias smithii* (n=2) (family Leptochariidae) (but the species identification is not confirmed), smooth-hound, *Mustelus sp.* (n=41) (family Triakidae) and blue shark, *Prionace glauca* (n=7) (family Carcharhinidae).

Capture locations were primarily in the waters off Pescara, some additional captures occurred in the waters of such nearby localities as Giulianova (35 km north of Pescara), Silvi Marina (10 km north of Pescara) and Ortona (16 km south of Pescara) (Fig. 1).

The data collected are presented in Tab. 1. For each specimen, the following data are reported: species, number of specimens (No.), capture date, capture location, sex (M or F), total length in cm, data source (when not directly collected by G. C.) and additional notes.

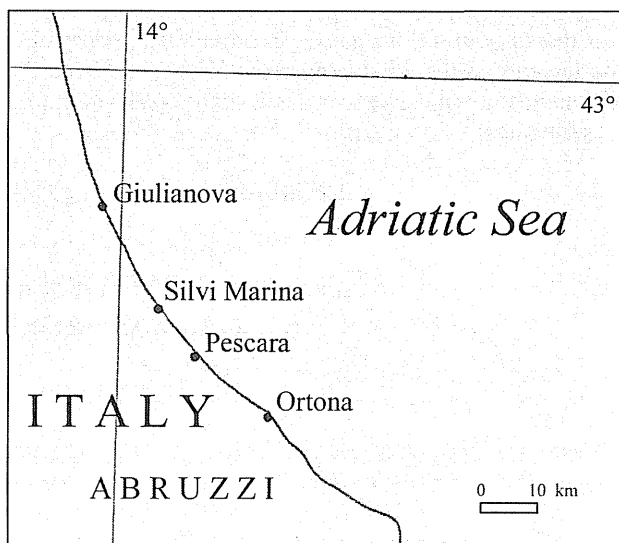


Fig. 1: Area of Pescara, Italy, on the Western Adriatic Sea coast. (Drawing: A. De Maddalena).

Sl. 1: Območje Pescare, Italija, na zahodni jadranski obali. (Risba: A. De Maddalena).

**Tab. 1: Sharks captures off Pescara (Italy, Western Adriatic Sea) recorded during the study period (May 2000 – March 2003).****Tab. 1: Morski psi, ujeti v vodah blizu Pescara (Italija, zahodni Jadran) in zabeleženi v preučevanem obdobju (maj 2000 – marec 2003).**

SPECIES	No.	DATE	LOCATION	SEX	TOTAL LENGTH (cm)	SOURCE	NOTES
<i>Prionace glauca</i>	1	May 2000	Pescara	-	275		Photographed.
<i>Prionace glauca</i>	2	Summer 2000	Pescara	-	ca. 200		Caught by sport-fishermen.
<i>Lamna nasus</i>	1	Summer 2000	Pescara	-	<200		Caught by sport-fishermen.
<i>Prionace glauca</i>	1	August 2000	Ortona	-	150		Photographed.
<i>Oxyrinotus centrina</i>	1	October 2000	Pescara	F	50-60	F. Lodi (pers. comm.)	Pregnant, carrying 5 embryos.
<i>Cetorhinus maximus</i>	1	End of November 2000	Pescara	-	500	F. Lodi (pers. comm.)	Landed already cut in pieces.
<i>Leptocharias smithii</i> (?)	2	April 26 <sup>th</sup> 2001	Pescara	-	ca. 100		Black-spotted coloration. The species identification is doubtful.
<i>Lamna nasus</i>	1	May 8 <sup>th</sup> 2001	Pescara	M	ca. 150		Weight: 35 kg.
<i>Squalus acanthias</i>	1	May 2001	Pescara	F	ca. 70		
<i>Alopias vulpinus</i>	1	June 2001	Pescara	-	350	E. Ballone (pers. comm.)	
<i>Scyliorhinus sp.</i>	20 ca.	July 2001	Pescara	M & F	-		
<i>Cetorhinus maximus</i>	1	November 2001	Pescara	-	500		Caught by fishing vessel "Nausicaa". Photographed.
<i>Lamna nasus</i>	1	December 2001	Pescara	F	ca. 250		Filmed. Total length estimated from the video.
<i>Cetorhinus maximus</i>	1	December 20 <sup>th</sup> 2001	Pescara	-	700		Filmed (Fig. 2).
<i>Mustelus sp.</i>	1	Mid January 2002	Pescara	M	120		Black-spotted coloration. Photographed.
<i>Hexanchus griseus</i>	1	January 22 <sup>nd</sup> 2002	Pescara	F	350		Photographed (Fig. 3).
<i>Hexanchus griseus</i>	1	January 22 <sup>nd</sup> 2002	Pescara	M	-		
<i>Lamna nasus</i>	1	February-March 2002	Giulianova	-	180	"Remo" (pers. comm.)	Caught by fisherman "Remo".
<i>Scyliorhinus canicula</i>	20 ca.	18 <sup>th</sup> April 2002	Pescara	-	-		
<i>Scyliorhinus stellaris</i>	1	23 <sup>rd</sup> April 2002	Pescara	-	ca. 120		
<i>Centrophorus sp.</i>	1	23 <sup>rd</sup> April 2002	Pescara	-	ca. 100		
<i>Prionace glauca</i>	1	11 <sup>th</sup> July 2002	Pescara	-	ca. 350		Caught about 20 miles offshore. Photographed (Fig. 4).
<i>Prionace glauca</i>	1	21 <sup>st</sup> July 2002	Giulianova	-	150	"Remo" (pers. comm.)	Caught by fisherman "Remo".
<i>Prionace glauca</i>	1	21 <sup>st</sup> July 2002	Giulianova	-	240		
<i>Hexanchus griseus</i>	1	28 <sup>th</sup> August 2002	Pescara	-	ca. 100		Weight: 80 kg.
<i>Hexanchus griseus</i>	1	25 <sup>th</sup> September 2002	Pescara	-	ca. 170		
<i>Mustelus sp.</i>	8	3 <sup>rd</sup> October 2002	Pescara	F	100 to 120		Caught inshore.
<i>Hexanchus griseus</i>	1	10 <sup>th</sup> October 2002	Pescara	F	ca. 450-500		
<i>Mustelus sp.</i>	3	14 <sup>th</sup> November 2002	Pescara	F	ca. 100		
<i>Hexanchus griseus</i>	1	19 <sup>th</sup> November 2002	Pescara	-	200		
<i>Squalus acanthias</i>	1	3 <sup>rd</sup> December 2002	Pescara	F	ca. 100		
<i>Mustelus sp.</i>	1	3 <sup>rd</sup> December 2002	Pescara	F	50		
<i>Squalus acanthias</i>	1	9 <sup>th</sup> January 2003	Pescara	F	ca. 120		Caught about 10 miles offshore.
<i>Squalus acanthias</i>	2	9 <sup>th</sup> January 2003	Pescara	-	-		Caught about 10 miles offshore.
<i>Mustelus sp.</i>	4	9 <sup>th</sup> January 2003	Pescara	-	-		Caught about 10 miles offshore.
<i>Squalus acanthias</i>	30	16 <sup>th</sup> January 2003	Pescara	-	-		Caught offshore.
<i>Mustelus sp.</i>	1	16 <sup>th</sup> January 2003	Pescara	F	120		Black-spotted coloration.
<i>Hexanchus griseus</i>	1	23 <sup>rd</sup> January 2003	Pescara	-	ca. 200		Landed already cut in pieces.
<i>Hexanchus griseus</i>	1	25 <sup>th</sup> February 2003	Pescara	-	ca. 200		Landed already cut in pieces.
<i>Mustelus sp.</i>	1	26 <sup>th</sup> February 2003	Pescara	-	ca. 150		Weight: over 15 kg.
<i>Mustelus sp.</i>	20	27 <sup>th</sup> February 2003	Pescara	-	ca. 50		Caught inshore.
<i>Mustelus sp.</i>	2	6 <sup>th</sup> March 2003	Pescara	-	ca. 120		



Tab. 2: Additional shark captures recorded during the study for the species that had occurred off Pescara, Giulianova and Silvi Marina in previous years.

Tab. 2: Morski psi, ki so se pojavljali v vodah v bližini Pescare, Giulianove in Silvi Marine v letih pred preučevanim obdobjem.

SPECIES	No.	DATE	LOCATION	SEX	TOTAL LENGTH (cms)	SOURCE	NOTES
<i>Carcharodon carcharias</i>	1	Around 1945	Pescara	-	ca. 600	V. Pomante (pers. comm.)	Caught by fisherman Vittorio Pomante.
<i>Isurus oxyrinchus</i> or <i>Lamna nasus</i>	3	1958	Pescara	-	-	V. Pomante (pers. comm.)	Caught within a week by fisherman Vittorio Pomante.
<i>Alopias vulpinus</i>	1	1987	Giulianova	-	600	"Remo" (pers. comm.)	Caught by fisherman "Remo".
<i>Prionace glauca</i>	1	1995	Giulianova	-	340	"Remo" (pers. comm.)	Caught by fisherman "Remo".
<i>Alopias vulpinus</i>	1	1997	Silvi Marina	-	416		Caught by sportfishermen. Photographed.
<i>Prionace glauca</i>	1	1999	Silvi Marina	-	270		Caught by sportfishermen. Photographed.
<i>Alopias vulpinus</i>	1	Summer 1999	Pescara	-	ca.300		Caught by sportfishermen.
<i>Alopias vulpinus</i>	1	2000	Silvi Marina	-	330		Caught by sportfishermen. Photographed.

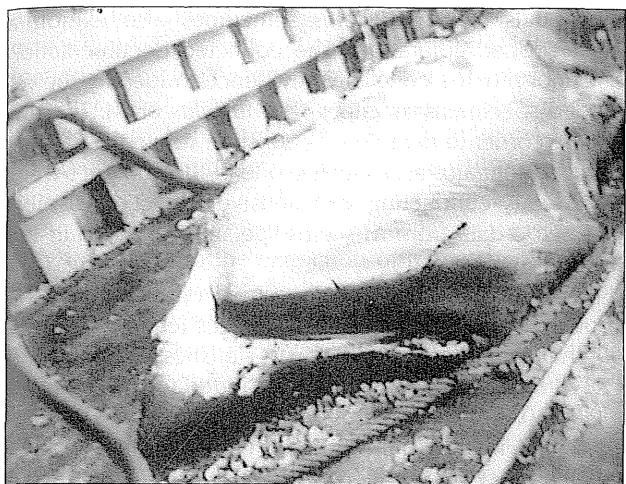
While we collected data on sharks captured during this study period, we also had the opportunity to gather information concerning some captures that had occurred in previous years in the waters off Pescara, Giulianova and Silvi Marina. These captures included members of the following species: blue shark, *Prionace glauca*, common thresher shark, *Alopias vulpinus*, white shark, *Carcharodon carcharias*, as well as other lamnid sharks not clearly identified but possibly either shortfin mako, *Isurus oxyrinchus* or porbeagle, *Lamna nasus*. These additional data are presented in Tab. 2.

DISCUSSION

The number of sharks captured off Pescara from May 2000 to March 2003 and the percentage of each species of the total shark captures are presented in Tab. 3.

The most abundant sharks in the area off Pescara are those of small and medium size: *Mustelus sp.* (28.47% of total captures), the catsharks (*Scyliorhinus canicula*, *S. stellaris* and *S. sp.*, 28.47%) and *Squalus acanthias* (24.30%). Large sharks are less abundant: *Hexanchus griseus* (5.55%), *Prionace glauca* (4.86%), *Lamna nasus* (2.77%), *Cetorhinus maximus* (2.08%) (Fig. 2), *Alopias vulpinus* (0.69%). Our data suggest that the rarest species in the area are *Oxynotus centrina* (0.69%) and

*Centrophorus sp.* (0.69%). Two specimens were initially identified as *Leptocharias smithii*, but a subsequent inquiry suggests that the species identification is doubtful. Therefore, the presence of *L. smithii* in the Adriatic Sea should be regarded as doubtful and requiring further investigation. We note that in this zone, as observed along other parts of the Italian coast (A. De Maddalena, *unpubl. data*), *H. griseus* appears to be relatively abundant, despite the fact that it is a species of conspicuous size. The paucity of captures of *P. glauca* observed in this study may present cause for concern for this species, since it is usually considered to be the most common large shark by far in the Western Adriatic. We also draw attention to the four captures of *L. nasus*. Recently, Marconi & De Maddalena (2001) reported the capture of a young, 91 cm female porbeagle that occurred off San Benedetto del Tronto (60 km North of Pescara) in July 2001, while this study was being conducted. It is very interesting to note that all these captures occurred within a relatively small area, since the porbeagle has usually been described as particularly rare in the Adriatic Sea (Tortonese, 1956; Pallaoro & Jardas, 1996; Soldo & Jardas, 2002; L. Lipej, *pers. comm.*; A. Soldo, *pers. comm.*). It is evident that in this area *L. nasus* is at present surely more common than previously believed.



**Fig. 2:** Basking shark, *Cetorhinus maximus* (ca. 700 cm), caught off Pescara (Italy, Western Adriatic Sea) on December 20<sup>th</sup> 2001. (Photo reproduced by kind permission of M. Di Giovanni)

**Sl. 2:** Približno 700 cm dolg morski pes orjak *Cetorhinus maximus*, ujet nedaleč od Pescare (Italija, zahodni Jadran) 20. decembra 2001. (Fotografija s prijaznim dovoljenjem M. Di Giovannija)

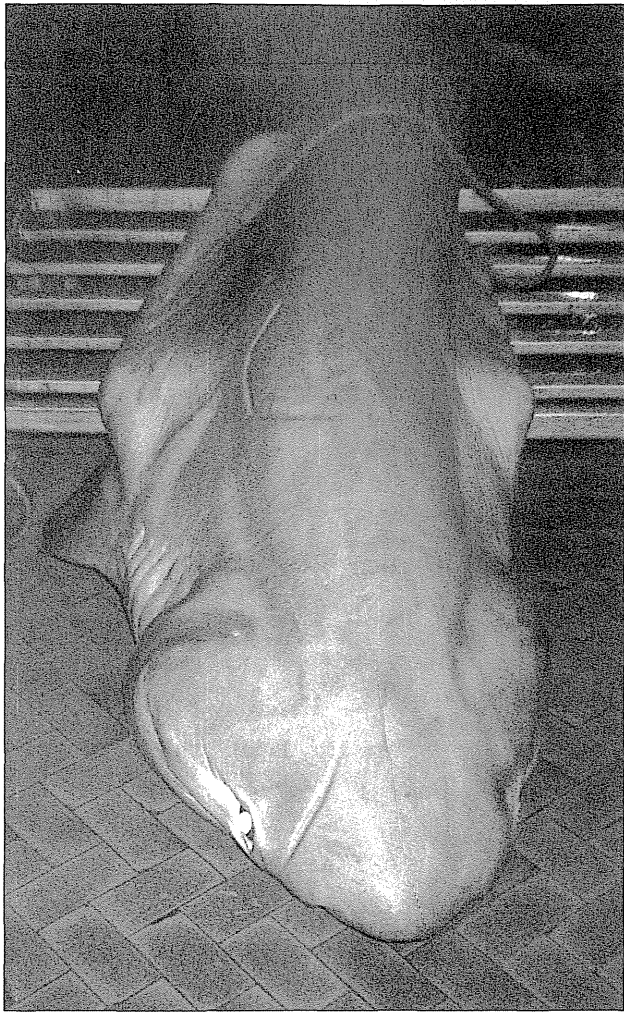
**Tab. 3:** Number of shark specimens captured off Pescara (Italy, Western Adriatic Sea) recorded during the study period (May 2000 - March 2003), by species and percentage of total shark captures.

**Tab. 3:** Število vrst morskih psov, ujetih v vodah blizu Pescare (Italija, zahodni Jadran) in zabeleženih med preučevanim obdobjem (maj 2000 - marec 2003) po vrstah in odstotkih njihovega skupnega ulova.

SPECIES	No.	%
<i>Hexanchus griseus</i>	8	5.55
<i>Centrophorus</i> sp.	1	0.69
<i>Squalus acanthias</i>	35	24.30
<i>Oxynotus centrina</i>	1	0.69
<i>Alopias vulpinus</i>	1	0.69
<i>Cetorhinus maximus</i>	3	2.08
<i>Lamna nasus</i>	4	2.77
<i>Scyliorhinus canicula</i>	20	13.89
<i>Scyliorhinus stellaris</i>	1	0.69
<i>Scyliorhinus</i> sp.	20	13.89
<i>Leptocharias smithii</i> (?)	2	1.39
<i>Mustelus</i> sp.	41	28.47
<i>Prionace glauca</i>	7	4.86

The lengths of all specimens fell within the ranges previously described for these species. The female *H. griseus* caught on 10 October 2002 and measuring between 450 and 500 cm, is close to the maximum size reported in the literature for this species (at least 482 cm

according to Compagno, 1984). We emphasize the fact that five of the recorded smooth-hound specimens exceeded 100-cm length and one measured approximately 150 cm. This further confirms that large smooth-hounds are not uncommon in the Adriatic Sea: the largest *Mustelus mustelus* (165 cm total length) recorded from the entire Mediterranean Sea was captured in the Adriatic (De Maddalena et al., 2001a). Also of interest is the capture of a 600-cm *Alopias vulpinus* that occurred off Giulianova in 1987. Compagno (1984) reported a maximum length for this species of at least 549 cm and possibly as much as 610 cm. Unfortunately in our case, the reported length was only an approximate one and the lack of photographic evidence does not allow us



**Fig. 3:** A female bluntnose sixgill shark, *Hexanchus griseus* (350 cm in length), caught off Pescara (Italy, Western Adriatic Sea) on January 22<sup>nd</sup> 2002. (Photo: G. Cugini)

**Sl. 3:** 350 cm dolga samica šesteroškrgarja *Hexanchus griseus*, ujeta pri Pescari (Italija, zahodni Jadran) 22. januarja 2002. (Foto: G. Cugini)

to report a conclusive size. The capture of a 600 cm *Carcharodon carcharias* that occurred sometime in 1945 off Pescara, is also of interest; this species reaches at least 640-660 cm TOT and very probably even more (De Maddalena *et al.*, 2001a). However, as in many other cases of white shark specimens reported to be of very large size, the reported length is approximate, and the lack of photographic evidence precludes reporting a definite length. Two large *Prionace glauca*, one measuring 340 cm and the other approximately 350 cm (they were caught in 1995 and on 11 July 2002 respectively and both documented by photographic evidence), also merit mention (Fig. 4). Finally we note the large approximately 120 cm female *Squalus acanthias* caught on 9 January 2003.

Two of the smooth-hounds, *Mustelus sp.* (one caught in mid-January 2002 and another on 16 January 2003) exhibited a black-spotted coloration that, according to Compagno (1984), is typical of the blackspotted smooth-hound, *Mustelus punctulatus*. However, according to more recent observations, *M. punctulatus* may not be acceptable as a recognized species, since there is not sufficient morphological difference between it and the other smooth-hound species present in the Mediterranean area (J. Barrull & I. Mate, *pers. comm.*; Barrull & Mate, 2002). Moreover, Tortonese (1956) reported that

individuals of *M. mustelus* sometimes also exhibit a black-spotted coloration. The collected documentation does not provide conclusive evidence to identify the recorded specimens as either *M. mustelus* or *M. punctulatus*. In order to definitely establish or refute the validity of *M. punctulatus* as a species, one of the authors (A. D.) is currently conducting an extensive collection of morphometric data from *Mustelus* specimens caught in the Mediterranean Sea.

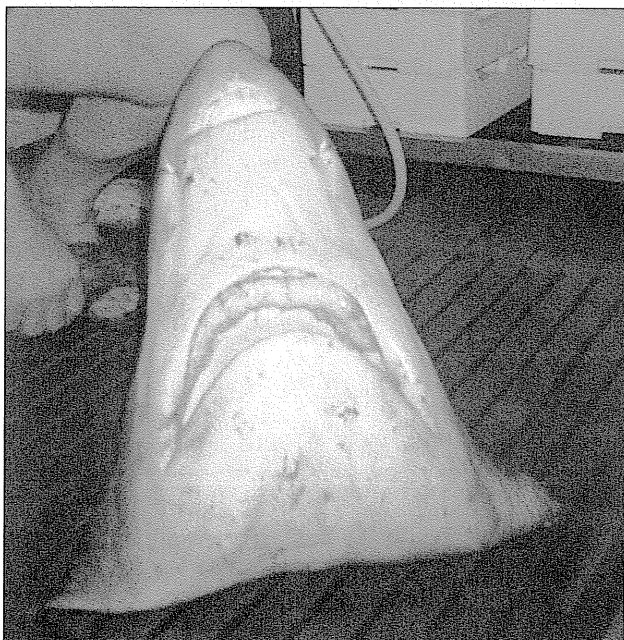
In Italy, shark meat is consumed in all parts of the country; moreover, Italy is the world's leading importer of sharks, according to FAO statistics (Vannuccini, 1999). In Pescara, as has been reported for other Italian regions (Vannuccini, 1999; De Maddalena & Piscitelli, 2001), the meat of most sharks is marketed and sold under incorrect names. Thus, not just *Mustelus sp.*, but also *Lamna nasus*, *Alopias vulpinus*, *Prionace glauca*, *Hexanchus griseus* and maybe *Leptocharias smithii* are usually sold as "palombo" (smooth-hound). Exceptions to this practice are *Squalus acanthias* and *Scylliorhinus sp.*, which are usually sold under their correct common names of "spinarolo" (piked dogfish) and "gattuccio" (catshark).

## CONCLUSIONS

The study of sharks from commercial fisheries and, secondarily, from sportfisheries permits monitoring of the state of local shark populations. The continuous long-term analysis we have conducted provides information on occurrence, relative abundance and fisheries status of some shark species occurring in the study area. The study we present here has been conducted in a relatively simple manner; consequently the results show some incompleteness and approximations. One reason for this is the fact that all of the work for this project has been accomplished through the present time without any support from public or private institutions.

Sharks are being overfished in many parts of the world. As bony fish fisheries have been depleted, fishermen have compensated increasing shark captures. An estimated 50% of the world shark catch is believed to be taken as bycatch, caught accidentally while fishing for other commercial species such as tuna and swordfish. The reproductive biology of sharks (long sexual maturation times, low fecundity, long gestation periods and relatively small litter size) makes them extremely vulnerable to such pressure. Thus, shark stocks are unable to withstand protracted periods of overexploitation.

The apparent decline of shark numbers warrants an urgent investigation into the status of the species involved. Effective conservation and management of shark fisheries is based on research upon the biology, ecology, distribution, abundance and exploitation of sharks. Shark research is often neglected in favour of study of the more commercially important bony fishes despite



**Fig. 4:** Head of a ca. 350 cm blue shark, *Prionace glauca*, caught off Pescara (Italy, Western Adriatic Sea) on 11 July 2002. (Photo: G. Cugini)

**Sl. 4:** Glava kakih 350 cm dolgega sinjega morskega psa *Prionace glauca*, ujetega v bližini Pescare (Italija, zahodni Jadran) 11. julija 2002. (Foto: G. Cugini)

the fact that sharks play an important role in marine ecosystems. There is a critical need for biological information on the life history of many shark species in order to better assess stock status and harvest impact. It is also necessary to better manage fisheries in which sharks constitute a significant bycatch (Rose, 1996; Vannucini, 1999; Watts, 2001). Lack of research and management in many countries, such as is sadly the case in Italy, may lead to the extinction of many shark species. At least 41 species of sharks occur in Italian waters, but there is evidence that many of these have strongly declined during the twentieth century (A. De Maddalena, *unpub. data*). Among these we can cite the sandtiger shark, *Carcharias taurus*, smalltooth sandtiger, *Odontaspis ferox*, white shark, *Carcharodon carcharias*, shortfin mako, *Isurus oxyrinchus*, porbeagle, *Lamna nasus*, tope shark, *Galeorhinus galeus*, sandbar shark, *Carcharhinus*

*plumbeus*, blue shark, *Prionace glauca*, smooth hammerhead, *Sphyrna zygaena*, bramble shark, *Echinorhinus brucus* and angular roughshark, *Oxynotus centrina*.

#### ACKNOWLEDGMENTS

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### MORSKI PSI, UJETI V BLIŽINI PESCARA (ITALIJA, ZAHODNI JADRAN)

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#### POVZETEK

Avtorja predstavljata rezultate študije morskih psov, ujetih v vodah nedaleč od Pescara (Italija, zahodni Jadran) med majem 2000 in marcem 2003. Ujetih je bilo 144 morskih psov najmanj 11 različnih vrst: navadnih morskih psov (*Mustelus sp. in morda Leptocharias smithii*, 29,86% celotnega ulova), morskih mačk (*Scyliorhinus canicula*, *S. stellaris in S. sp.*, 28,47%), *Squalus acanthias* (24,30%), *Hexanchus griseus* (5,55%), *Prionace glauca* (4,86%), *Lamna nasus* (2,77%), *Cetorhinus maximus* (2,08%), *Alopias vulpinus* (0,69%), *Oxynotus centrina* (0,69%) in *Centrophorus sp.* (0,69%). Avtorja sta hkrati dobila priložnost zbrati nekaj informacij glede ulova vrst *P. glauca*, *A. vulpinus*, *Carcharodon carcharias in* nekaterih neidentificiranih lamnidov, ki so se v teh vodah pojavljali v prejšnjih letih. Vse kaže, da je morski pes šesteroškrkar tu razmeroma številčen, medtem ko je skušolovec pogostejši, kot so sprva domnevali. Po drugi strani pa je maloštevilnost ujetih sinji morskih psov vsekakor razlog za zaskrbljenost.

**Ključne besede:** morski psi, ribištvo, Italija, Jadransko morje, Sredozemsko morje

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## SPATIAL DISTRIBUTION OF SOFT-BOTTOM POLYCHAETES ALONG WESTERN COAST OF THE NORTHERN ADRIATIC SEA (ITALY)

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### ABSTRACT

*The composition and spatial distribution of soft bottoms polychaetes in the northwestern Adriatic Sea are described. The basin is characterized by shallow depths (mean depths 33.5 m), high river inputs along the western coast, large annual temperature variations and water stratification during the summer. The sediment composition varied from muds to sands. A total of 135 species, belonging to 37 families, were identified; the average density and biomass were respectively 313 ind. m<sup>-2</sup> and 17.6 g WW m<sup>-2</sup>. The cluster analysis on abundance data resulted in four main groups of stations, characterized by different sets of organisms and sediment features. The river inputs and depth seem to be particularly important in structuring these bottom populations.*

**Key words:** polychaetes, distribution, soft-bottom, Adriatic Sea

## DISTRIBUZIONE SPAZIALE DEI POLICHETI DI FONDI MOBILI LUNGO LA COSTA OCCIDENTALE DELL'ADRIATICO SETTENTRIONALE (ITALIA)

### SINTESI

*Nel presente lavoro viene descritta la composizione e la distribuzione dei policheti di fondi mobili nell'Adriatico Nord occidentale. Il bacino è caratterizzato da profondità non elevate, cospicui apporti fluviali lungo il versante occidentale, ampie variazioni di temperatura e stratificazione della colonna d'acqua durante l'estate. La composizione tessiturale del sedimento varia da fanghi a sabbie. Sono state identificate 135 specie appartenenti a 37 famiglie; la densità media e la biomassa erano rispettivamente di 313 ind. m<sup>-2</sup> e 17.6 g m<sup>-2</sup> di peso umido. L'analisi multivariata sui dati di abbondanza ha rilevato quattro gruppi principali di stazioni, caratterizzati da una diversa composizione degli organismi e dei sedimenti. Gli apporti continentali e la profondità sembrano particolarmente importanti nella caratterizzazione di queste comunità di fondo.*

**Parole chiave:** policheti, distribuzione, fondi mobili, Mare Adriatico

## INTRODUCTION

The northern Adriatic Sea is characterized by shallow depths (mean depth 33.5 m and maximum depth 70 m) and considerable river inputs. These inputs are particularly important on the western coast where the Po River discharges 50% of the total freshwater flow in the northern Adriatic and is the most important allochthonous source of organic matter and nutrients for the entire Mediterranean Sea (Pagnotta *et al.*, 1999).

The shores are predominantly sandy along the northwestern coast and the deposition of fine material from northern rivers is relatively poor, settling along a discontinuous narrow belt. In the area influenced by the Po River, the belt of fine bottom sediments becomes larger and extends southwards. Offshore shelf sands are present (Frignani & Frascari, 1990).

The main oceanographic features of the basin are the annual variation in the density structure of the water column, characterized by a strong summer stratification and a dynamic separation between the waters of the basin proper and the coastal zone (Franco & Michelato, 1992).

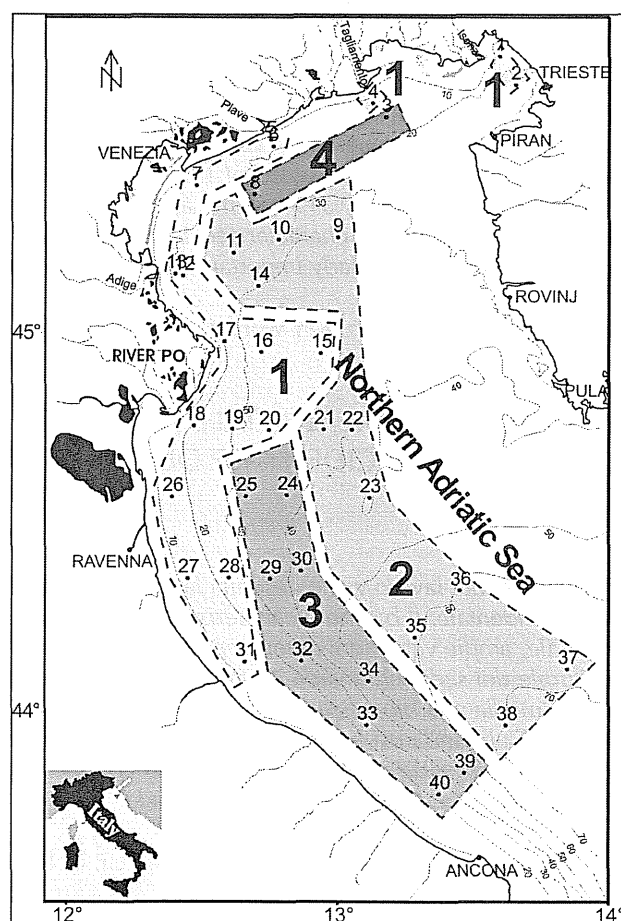
The northern Adriatic Sea is undergoing considerable anthropic pressure due to nutrients loading (urban and agricultural development) (Degobbi *et al.*, 2000), commercial fishing and tourism, including the infrastructure to support it. Furthermore, oxygen depletion deriving from natural hydrological processes and/or eutrophication mainly for the area influenced by the Po (Faganeli *et al.*, 1985; Degobbi *et al.*, 1991; Justić, 1991; Vollenweider *et al.*, 1992; Orel *et al.*, 1993a), periodically cause severe hypoxia and even anoxia in the bottom layers resulting in massive local benthos mortality (Aleffi *et al.*, 1992; Rinaldi *et al.*, 1993; Stachowitsch & Fuchs, 1995; Kollmann & Stachowitsch, 2001). In addition, the area is affected by occasional massive mucilage formations (Azam *et al.*, 1999; Degobbi *et al.*, 1999) which, sinking to the bottom, asphyxiate the benthic fauna (Orel *et al.*, 1993b). Despite this environmental stress, the northern Adriatic Sea has been characterized by a rich benthic fauna and studied since the 19th century. In 1934-1936, Vatova (1949) sampled the macrobenthic communities of the northern and middle Adriatic and defined some ecological units as "zoocenoses", based on the dominant species. Subsequent studies on benthic communities have been either localized (Fedra *et al.*, 1976; Aleffi *et al.*, 1996; Mancinelli *et al.*, 1998; Moodley *et al.*, 1998) or very general; in the latter, different data sets have been analysed together to achieve a comprehensive overview of the northern Adriatic benthos (Orel *et al.*, 1987; Scardi *et al.*, 2000). However, regarding the Polychaeta fauna, previous studies have been carried out only for some species and in narrow areas along the northwestern coast (Ambrogi *et al.*, 1993; Castelli *et al.*, 1999). On the contrary,

along the northeastern coast, mainly characterized by rocky shores, the first surveys on polychaetes started in the 19<sup>th</sup> century (Grube, 1840, 1861), and were followed in the 20<sup>th</sup> century by numerous taxonomic studies; among the most important, we can cite: Fauvel (1934, 1940), Amoureux & Katzmann (1971), Amoureux (1975, 1976), Bellan (1969) and Požar-Domac (1978).

The present study constitutes the first comprehensive survey carried out along the western coast of the northern Adriatic (from Trieste to Ancona) in order to determine the composition, structure and spatial distribution of the soft bottoms polychaetes.

## MATERIAL AND METHODS

Within the framework of the PRISMA 1 Project (financed by the Italian Ministry of Research), carried out in May 1995, forty stations were sampled along the



**Fig. 1:** Map of the study area showing the sampling stations. The four delimited areas (1, 2, 3, 4) correspond to the dendrogram groups.

**Sl. 1:** Zemljevid obravnavanega območja z vzorčevalnimi postajami. Štiri označeni predeli (1, 2, 3, 4) ustrezajo skupinam v dendrogramu.

western Adriatic coast, at depths ranging from 12 to 70 m (Fig. 1). At each station, five samples were collected with a 0.1 m<sup>2</sup> van Veen grab, sieved through a 1 mm mesh and preserved in buffered 4% formalin. Biomass (wet weight: WW) determinations were made by weighing formalin-preserved samples, following blotting on absorbent paper. Abundances were adjusted to 1 m<sup>2</sup>. Species were grouped in feeding guilds according to Fauchald & Jumars (1979). Four main groups were considered: suspension feeders (SF), surface-deposit feeders (SDF), subsurface-deposit feeders (SSDF) and carnivores/omnivores (C). The sediment textural characteristics were taken both from Brambati *et al.* (1983) and Frascari *et al.* (2000). The latter analysed the sediment features in the same PRISMA 1 Project.

Univariate analyses used included: number of species, as a measure of alpha diversity, abundance and biomass. Multivariate analysis was performed using the Bray-Curtis similarity index on double square root transformed abundance data, using group-average clustering (PRIMER software package developed at the Plymouth Marine Laboratory) on the species determined for each station.

## RESULTS AND DISCUSSION

At all stations, the polychaetes dominated in species number in comparison with other main macrobenthic taxonomic groups, such as molluscs, crustaceans and echinoderms (Fig. 2). A total of 6260 polychaetes were collected and 135 species were determined from 37 families. The dominant family in terms of species richness and abundance was by far Spionidae with 17 spe-

cies and a total of 702 organisms (11.3% of the total), followed by Maldanidae and Sabellidae both with nine species and 507 (8.1%) and 273 (4.3%) individuals respectively. The most frequent species were *Lumbrineris gracilis* (75%), *Ampharete acutifrons* (63%), *Spiophanes kroyeri* (63%), *Levinsenia gracilis* (60%), *Spiochaetopterus costarum* (58%) and *Melinna palmata* (58%) (Append. 1).

The number of species varied from 51 in st. 10 to only 3 species in st. 25. The highest values were found in zones A and B (Fig. 3). The average density was 313 ind. m<sup>-2</sup> with maximum values of 1,420 ind. m<sup>-2</sup> (st. 9) and minimum values of 56 ind. m<sup>-2</sup> (st. 25); the highest densities were observed in the same two areas (A and B), in which the highest number of species was found (Fig. 4). These two zones are characterized by mixed sediments where sands dominate (Brambati *et al.*, 1983), constituting a quite heterogeneous habitat and thus favouring higher species richness than fine and homogeneous sediments (Gray, 1974). Despite this fact, in A and B both the number of species and density are higher than would have been expected, since they are located offshore in deeper areas (25-30 m in A and 40-50 m in B) while in general, shallow coastal zones directly influenced by river inputs, where organic matter content is high, as in the vicinity of the Po delta, could be thought to be more favourable for the development of those populations. In addition, zone A is considered an area of sedimentary instability, due to the effects of anthropic factors, such as trawling fisheries and the long term effects of dumping operations carried out for years and stopped a couple of years before this study was initiated.

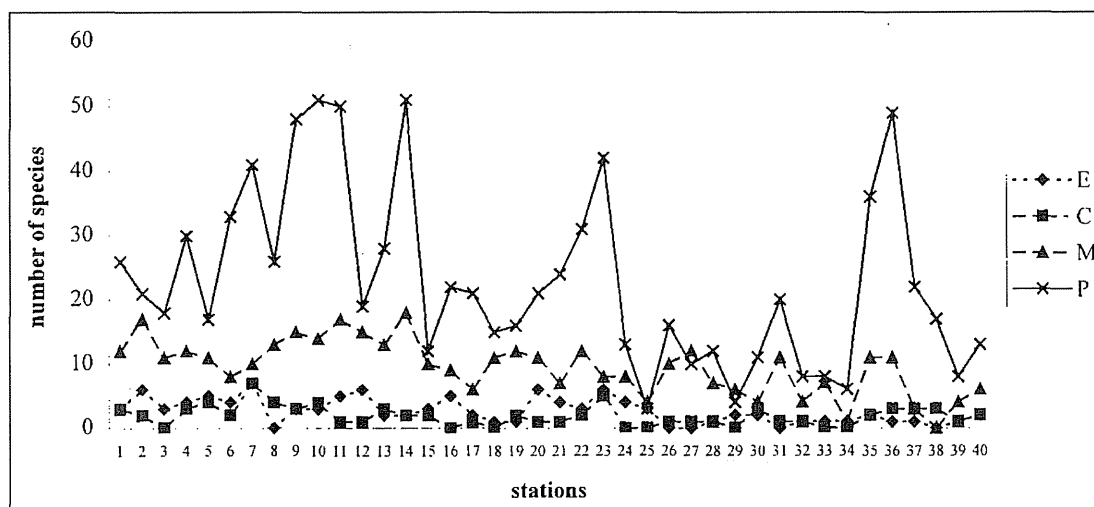


Fig. 2: Number of species of the main macrobenthic taxa (polychaetes, molluscs, crustaceans, echinoderms) at each station.

Sl. 2: Število vrst glavnih makrobentoških taksonov (mnogoščetinci, mehkužci, raki in iglokožci) na posamezni postaji.



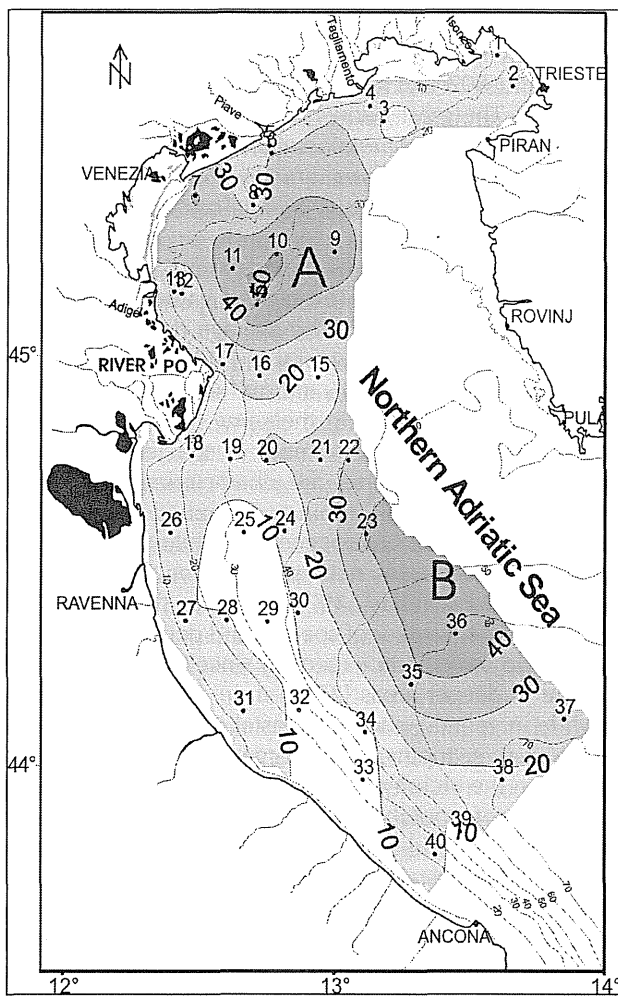


Fig. 3: Contours of the species richness; A and B indicate the zones of highest values.

Sl. 3: Vrstna pestrost; A in B označujeta cone z največjo gostoto.

The average biomass was  $17.6 \text{ g WW m}^{-2}$ , with considerable differences among the stations. The highest value was  $172.8 \text{ g WW m}^{-2}$  in st. 1, due to the presence of the tube-dwelling polychaete *Chaetopterus variopeatus*, whereas the minimum value of  $1.73 \text{ g WW m}^{-2}$  was found at st. 15, where density was also low. The biomass values can help explain the evident differences found between muddy and prevalently sandy bottoms, since densities are highest in fine sands, but with lower values of biomass than in stations characterized by muddy sediments; this is mainly due to the prevalence of small size polychaetes.

Over the whole area, the dominant species were: *Owenia fusiformis*, characteristic of sandy sediments, *Maldane glebifex*, characteristic of muddy bottoms, and *L. gracilis*, without any definite preference for a specific type of sediment.

Cluster analysis on abundance data evidenced four main groups of stations (Fig. 5) characterized by different community types and different sediment features. Area 1 (Fig. 1) was located along the coastline in muddy bottoms influenced by the main North Adriatic rivers inputs (Isonzo, Tagliamento, Piave, Adige, Po). The most abundant and frequent species of this community were: *M. glebifex*, *L. gracilis*, *S. costarum* and *A. acutifrons* (Tab. 1). The mean species richness in this group was 21 species, while average density was  $260 \text{ ind. m}^{-2}$ . The biomass was the highest ( $27 \text{ g WW m}^{-2}$ ), due to large species such as *C. variopeatus*, *Marphysa sanguinea* and *Glycera unicornis*.

Inside this wide group, differences were clear between stations located north and south of the Po River delta. The mean species number and density of the northern stations (st. 1-13) were, respectively, 27 species and  $358 \text{ ind. m}^{-2}$ , whereas lower values for both parameters (16 species,  $182 \text{ ind. m}^{-2}$ ) were recorded at the stations influenced by the Po. In the latter zone, high sedimentation rates, high organic matter inputs and periodic hypoxic conditions prevail so that the community is affected by environmental instability (Crema et al., 1991; Tahey et al., 1996).

In Area 2 (Fig. 1) sandy sediments dominated and diversity and density had the highest values, with averages of 38 species and  $554 \text{ ind. m}^{-2}$  (Tab. 2), while the biomass values were low due to the presence of smaller polychaetes than those found in Area 1. The most representative species were: *O. fusiformis*, *Myriochele oculata*, and *Nothria conchylega*, which prefer medium size muddy sands with shell debris (Glémarec, 1991; Ambrogi et al., 1995). In the deepest stations (60-70 m) *Aponuphis fauveli* was dominant ( $310 \text{ ind. m}^{-2}$  in st. 35) and replaced *A. bilineata* also found in the stations of this group, but at a maximum depth of 40 m.

The third group of stations (Area 3) is located along the offshore border of Area 1, south of the Po River delta. Muddy bottoms dominate as in Area 1, but in deeper waters (mean depths of 33 m versus 20 m in Area 1) and with lower organic matter content in the sediments (Frascari et al., 2000). The dominant species were: *Sthenolepis yhleni* and the burrowing polychaete *Sternaspis scutata*, which jointly represented 69% of the polychaetes abundance and 83% of the biomass. Diversity and density values were lower than in the other groups and reached an average value of 8 species and  $84 \text{ ind. m}^{-2}$ ; the biomass values were the lowest there.

Stations 3 and 8 (Area 4) constitute the smallest group in the dendrogram and are located in the area between the Isonzo River and the Gulf of Venice, at 10 to 25 m depth (Orel et al., 1987). This zone is characterized by coarse sandy bottoms with beachrocks, defined as medium to fine sandstones with carbonate cement by Brambati et al. (1983). The dominant species were *A. bilineata* and *Prionospio caspersi*; the latter was

Tab. 1: Distribution of the dominant species in the four areas identified by cluster analysis. (A) total abundance, (F) frequency as percentage of presences at the stations of each area.

Tab. 1: Rasprostranjenost dominantnih vrst na štirih predelih, opredeljenih z grozdičasto analizo. (A) celokupna abundanca, (F) frekvenca kot delež navzočnosti na postajah na vseh predelih.

Species	Area 1 (18 stations)		Area 2 (11 stations)		Area 3 (9 stations)		Area 4 (2 stations)	
	A	F	A	F	A	F	A	F
	(ind. m <sup>-2</sup> )	(%)	(ind. m <sup>-2</sup> )	(%)	(ind. m <sup>-2</sup> )	(%)	(ind. m <sup>-2</sup> )	(%)
<i>Owenia fusiformis</i>	80	50	1004	73	2	11	8	50
<i>Lumbrineris gracilis</i>	650	94	252	91	6	22	4	50
<i>Maldane glebifex</i>	704	89	50	36	-	-	-	-
<i>Aponuphis fauveli</i>	-	-	586	36	18	11	-	-
<i>Ampharete acutifrons</i>	322	83	124	91	-	-	-	-
<i>Sthenolepis yhleni</i>	70	28	64	64	288	100	-	-
<i>Spiophanes kroyeri</i>	108	67	290	91	8	33	-	-
<i>Sternaspis scutata</i>	140	56	24	36	230	89	-	-
<i>Nothria conchylega</i>	6	6	384	64	-	-	-	-
<i>Spiochaetopterus costarum</i>	326	89	14	27	30	33	2	50
<i>Myriochele oculata</i>	26	39	316	82	2	11	-	-
<i>Laonice cirrata</i>	316	50	12	27	-	-	-	-
<i>Pseudoleiocardia fauveli</i>	288	50	6	18	-	-	-	-
<i>Aponuphis bilineata</i>	36	22	100	55	-	-	148	100
<i>Prionospio caspersi</i>	6	11	42	36	-	-	98	100

Tab. 2: Average values of species richness, density, biomass and depth in the four areas.

Tab. 2: Povprečne vrednosti vrstne pestrosti, gostote, biomase in globine na štirih predelih.

Area	No. stations	No. species	density (ind. m <sup>-2</sup> )	biomass (g WW m <sup>-2</sup> )	depth (m)
Area 1	18	21	260	27.56	20
Area 2	11	38	553	10.10	45
Area 3	9	8	84	8.39	33
Area 4	2	21	244	10.68	18

Tab. 3: Feeding guilds as percentage of density data (SF=suspension feeders, SDF=surface-deposit feeders, SSDF=subsurface-deposit feeders, C=carnivores/omnivores).

Tab. 3: Prehranjevalni cehi, izraženi kot delež gostote (SF=suspenzijofagi, SDF=vrste, ki se hranijo na površini sedimenta, SSDF=vrste, ki se hranijo tik pod površino, C=karnivori/omnivori).

Feeding guilds	SF (%)	SDF (%)	SSDF (%)	C (%)
Area 1	4	29	44	23
Area 2	25	19	19	37
Area 3	1	16	39	44
Area 4	11	34	10	45

recorded as particularly abundant in coastal sandy bottoms, up to 5 m depth, off the Po delta (Ambrogi et al., 1993). The average species richness, density and biomass were respectively 21 species, 244 ind. m<sup>-2</sup> and 10.68 g WW m<sup>-2</sup>.

The polychaete populations were dominated by the subsurface-deposit feeders (44%) and surface deposit feeders in Area 1, where the organisms can use as a direct food source the freshly deposited material coming from the rivers. Carnivores dominated in Areas 2 (37%), 3 (44%) and 4 (45%). Areas 2 and 4 were both characterized by prevalently sandy sediments, in which filter feeders reached the highest values (25% and 11%), while in Area 3 there was a balance between two trophic categories: carnivores (44%) and subsurface-deposit feeders (39%) (Tab. 3).

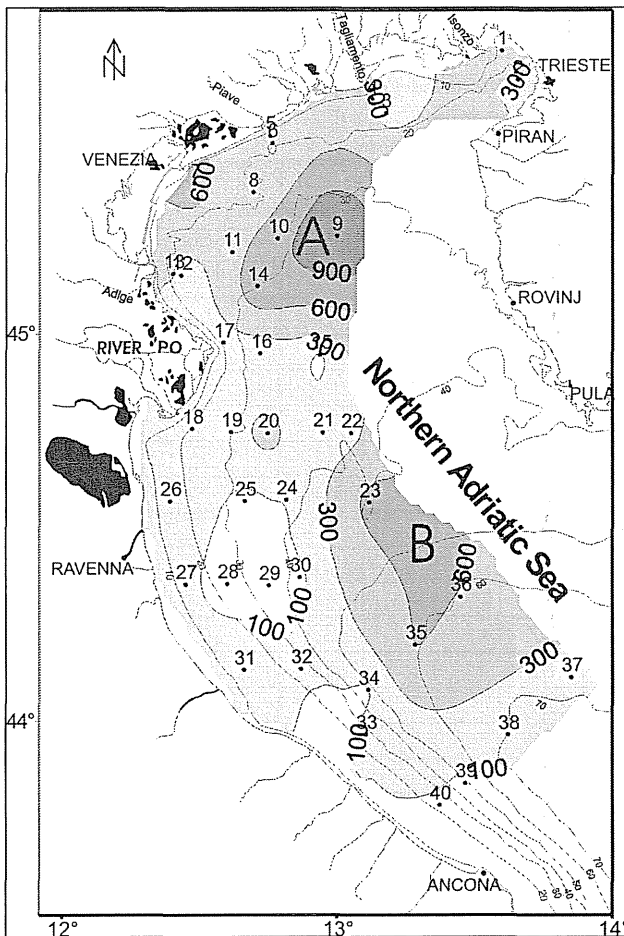


Fig. 4: Contours of density (ind. m<sup>-2</sup>). A and B indicate the zones of highest values.

Sl. 4: Gostota osebkov (os. m<sup>-2</sup>). A in B označujeta cone z največjo gostoto.

## CONCLUSIONS

The composition and ecological characteristics of the polychaetes in the study area evidenced four zones with different structures. The number of species and the densities were higher off the Venice Lagoon (Area 2), on prevalently sandy sediments. The populations found in muddy sediments were less rich especially south of the Po River delta (Area 1) and in deeper stations (Area 3). On the contrary, biomass was higher in muddy sediments, where the organic matter content is high. Two factors seem to be particularly important in structuring these populations: the influence of the Po (and secondarily of the other rivers input) and depth. The trophic structure was dominated by deposit-feeding polychaetes in the coastal area with muddy sediments, whereas on prevalently sandy sediments, carnivores and filter feeders prevailed.

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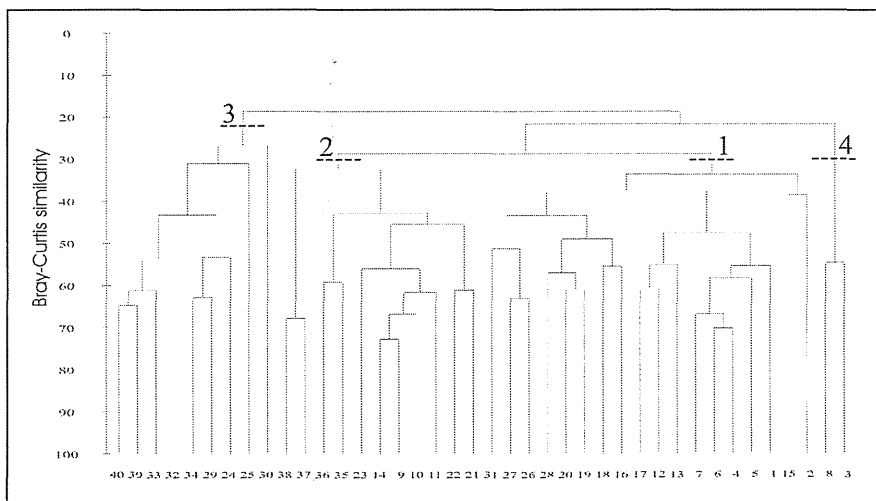


Fig. 5: Dendrogram of the 40 stations on abundance data.

Sl. 5: Dendrogram 40 vzorčevalnih postaj na podlagi podatkov abundance.

# PROSTORSKA RAZŠIRJENOST MNOGOŠČETINCEV (POLYCHAETA), NA MEHKEM DNU VZDOLŽ ZAHODNE OBALE SEVERNEGA JADRANSKEGA MORJA (ITALIJA)

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## POVZETEK

Avtorji članka opisujejo sestavo in prostorsko razširjenost mnogoščetincev, živečih na mehkem morskem dnu severozahodnega dela Jadranskega morja. Značilnosti tega morskega bazena so njegova plitkost (srednja globina 33,5 m), izdatni rečni vnosi vzdolž zahodne obale Jadranskega morja, velike letne temperaturne spremembe in razslojenost vodnega stolpca v poletnih mesecih. Poleg tega na to območje močno vplivajo ciklični pojavi, kot na primer sluzasti agregati in pomanjkanje kisika, kar lahko povzroča hudo hipoksijo ali celo anoksijo in zatorej množične pogine živih bitij v morju. Avtorji so raziskavo opravili maja 1995 na štiridesetih postajah z van Veenovim grabilom, pri čemer so vzorce precejevali skozi milimetrsko mrežico. Usedline so bile zelo raznolike – od blatnih do peščenih. Določili so 135 vrst, pripadajočih 37 družinam, s povprečno gostoto 313 os. m<sup>-2</sup> in povprečno biomaso 17,6 g mokre teže m<sup>-2</sup>. Posledica grozdčaste analize gostote posameznih vrst je bila razdelitev postaj na štiri glavne skupine z različnimi organizmi in značilnimi usedlinami na morskem dnu. Na sestavo teh talnih populacij sta še posebno vplivala rečni vnos in globina morja.

**Ključne besede:** mnogoščetinci, razširjenost, mehko dno, Jadransko morje

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**Append. 1: List of the polychaete species found in this study with their total abundance, frequency and distribution per area.**

**Priloga 1: Seznam ugotovljenih vrst mnogoščetincev s podatki o njihovi celokupni abundanci, frekvenci in razširjenosti po posameznih predelih.**

Family	Species	Tot. abund.	Frequency	Area
Ampharetidae	<i>Amage adspersa</i>	10	3	2
	<i>Ampharete acutifrons</i>	223	25	1,2
	<i>Amphicteis gunneri</i>	14	3	2
	<i>Melinna palmata</i>	93	23	1,2,3
	<i>Sabellides octocirrata</i>	5	4	1,2
	<i>Sosane sulcata</i>	19	6	2
Aphroditidae	<i>Laetmonice hystrix</i>	1	1	2
Arabellidae	<i>Arabella geniculata</i>	2	2	1,2
	<i>Drilonereis filum</i>	12	10	1,2,4
Capitellidae	<i>Dasybranchus caducus</i>	1	1	1
	<i>Heteromastus filiformis</i>	8	8	1,2
	<i>Notomastus latericeus</i>	103	13	1,2,3,4
	<i>Notomastus lineatus</i>	1	1	2
	<i>Notomastus</i> sp.	200	22	1,2,3,4
	<i>Pseudoleiocarditella fauveli</i>	147	11	1,2
	Capitellidae indet.	5	3	2,3,4
Chaetopteridae	<i>Chaetopterus variopedatus</i>	9	3	1,2
	<i>Mesochaetopterus sagittarius</i>	1	1	2
	<i>Spiochaetopterus costarum</i>	186	23	1,2,3,4
	Chaetopteridae indet.	5	3	1,2
Cirratulidae	<i>Aphelochaeta marioni</i>	28	10	1,2,3
	<i>Cautleriella bioculata</i>	3	1	4
	<i>Chaetozone setosa</i>	10	8	1,2,4
	<i>Dodecaceria concharum</i>	2	1	2
	<i>Monticellina dorsobranchialis</i>	1	1	1
	Cirratulidae indet.	116	25	1,2,3,4
Dorvilleidae	<i>Schistomeringos neglectus</i>	1	1	2
	<i>Scistomeringos rudolphii</i>	4	3	1,2
Eunicidae	<i>Eunice vittata</i>	101	14	1,2,3
	<i>Lysidice ninetta</i>	3	2	1,4
	<i>Marphysa bellii</i>	57	13	1,2,3
	<i>Marphysa sanguinea</i>	10	6	1
	<i>Nematonereis unicornis</i>	29	4	2
Flabelligeridae	<i>Pherusa monolifera</i>	6	3	1,2
	<i>Pherusa plumosa</i>	7	2	1,2
	<i>Piromis eruca</i>	1	1	2
Glyceridae	<i>Glycera alba</i>	7	4	2,3
	<i>Glycera capitata</i>	9	4	2,3
	<i>Glycera rouxii</i>	36	17	1,2,3
	<i>Glycera</i> sp.	15	8	1,2
	<i>Glycera tessellata</i>	1	1	2
	<i>Glycera tridactyla</i>	9	4	2,4
	<i>Glycera unicornis</i>	58	19	1,2,3,4
Goniadidae	<i>Goniada maculata</i>	61	9	1,2,4
	<i>Glycinde nordmanni</i>	1	1	2
Hesionidae	<i>Gyptis propinqua</i>	5	3	2
	<i>Ophiodromus flexuosus</i>	3	3	1,2,4
	Hesionidae indet.	3	2	1,2



Family	Species	Tot. abund.	Frequency	Area
Lumbrineridae	<i>Lumbrineris gracilis</i>	456	30	1,2,3,4
	<i>Lumbrineris latreillii</i>	86	17	1,2,4
	<i>Lumbrineris</i> sp.	2	2	1,3
	<i>Lumbrineris tetraura</i>	31	13	1,2,3
	<i>Ninoe kinbergi</i>	5	1	2
Magelonidae	<i>Magelona alleni</i>	24	11	1,2,3
	<i>Magelona minuta</i>	8	4	2
	<i>Magelona</i> sp.	5	5	1,2
Maldanidae	<i>Clymenura clypeata</i>	11	4	1,2
	<i>Euclymene lumbricoides</i>	4	2	2
	<i>Euclymene oerstedii</i>	34	4	1,2
	<i>Euclymene palermitana</i>	66	15	1,2,4
	<i>Maldane glebifex</i>	377	20	1,2
	<i>Metasychis gotoi</i>	1	1	2
	<i>Petaloproctus terricolus</i>	1	1	2
	<i>Praxillella affinis</i>	11	3	2
	<i>Praxillella lophoseta</i>	2	2	2
	Maldanidae indet.	106	16	1,2,3,4
Nephtyidae	<i>Micronephtys</i> sp.	4	3	1,2,4
	<i>Nephtys hombergi</i>	13	6	2
	<i>Nephtys hystericis</i>	79	20	1,2,3
	<i>Nephtys incisa</i>	28	6	1,2,3
	<i>Nephtys</i> sp.	14	4	1,2,3
Nereididae	<i>Ceratonereis costae</i>	1	1	1
	<i>Nereis lamellosa</i>	21	11	1,2,3
	<i>Nereis rava</i>	6	2	1,4
	<i>Nereis</i> sp.	5	4	1,2
	<i>Perinereis</i> sp.	9	5	1,2
Onuphidae	<i>Aponuphis bilineata</i>	142	12	1,2,4
	<i>Aponuphis fauveli</i>	302	5	2,3
	<i>Diopatra neapolitana</i>	3	2	1
	<i>Nothria conchylega</i>	195	8	1,2
	<i>Onuphis quadricuspis</i>	5	1	1
	<i>Onuphis</i> sp.	74	4	2
Opheliidae	<i>Ophelina cylindrica</i>	13	4	2
Orbiniidae	<i>Orbinia cuvieri</i>	2	2	1,4
	<i>Phylo foetida</i>	3	2	1
	<i>Scoloplos armiger</i>	2	1	2
Oweniidae	<i>Myriochele oculata</i>	172	17	1,2,3
	<i>Owenia fusiformis</i>	547	20	1,2,3,4
Paralacydoniidae	<i>Paralacydonia paradoxa</i>	73	11	1,2
Paraonidae	<i>Aricidea claudiae</i>	3	1	2
	<i>Aricidea mariannae</i>	157	1	4
	<i>Cirrophorus furcatus</i>	3	2	2
	<i>Levinsonia gracilis</i>	130	24	1,2,3,4
	<i>Paradoneis lyra</i>	58	14	1,2
	<i>Paraonides neapolitana</i>	2	2	1,2
	Paraonidae indet.	366	28	1,2,3,4
Pectinariidae	<i>Pectinaria auricoma</i>	37	10	1,2
	<i>Pectinaria belgica</i>	3	3	1,2
	<i>Pectinaria koreni</i>	12	8	1,2

Family	Species	Tot. abund.	Frequency	Area
Phyllodocidae	<i>Mysta picta</i>	10	4	1,2
	<i>Phyllodoce lineata</i>	7	7	1,2
	<i>Phyllodoce</i> sp.	2	2	1,2
	Phyllodocidae indet.	2	2	2
Pilargiidae	<i>Ancistrosyllis groenlandica</i>	77	14	1,2,3,4
	<i>Pilargis verrucosa</i>	9	8	1,2,3
Poecilochaetidae	<i>Poecilochaetus serpens</i>	38	18	1,2,3,4
Polynoidae	<i>Harmothoe</i> sp.	3	2	3
	Polynoidae indet.	55	24	1,2,4
Sabellidae	<i>Chone acustica</i>	1	1	2
	<i>Chone collaris</i>	22	7	1,2
	<i>Chone duneri</i>	109	13	1,2,4
	<i>Euchone rosea</i>	89	10	1,2
	<i>Euchone rubrocincta</i>	12	7	2,3
	<i>Jasmineira caudata</i>	2	2	2
	<i>Jasmineira elegans</i>	24	7	2,4
	<i>Megalomma vesiculosum</i>	11	8	1,2
	<i>Myxicola infundibulum</i>	3	1	4
	Sabellidae indet.	16	3	2
Scalibregmatidae	<i>Scalibregma inflatum</i>	10	2	2
Serpulidae	<i>Ditrupea arietina</i>	2	1	2
	<i>Hydroides norvegicus</i>	1	1	2
	<i>Pomatoceros triqueter</i>	4	2	1
	<i>Serpula concharum</i>	3	2	2
	<i>Serpula vermicularis</i>	3	3	1,4
Sigalionidae	<i>Psammolyce arenosa</i>	1	1	2
	<i>Sthenelais boa</i>	3	2	2,4
	<i>Sthenelais limicola</i>	16	4	2
	<i>Sthenelais minor</i>	3	1	2
	<i>Sthenelais</i> sp.	1	1	3
	<i>Sthenolepis yhleni</i>	211	21	1,2,3
Spionidae	<i>Laonice cirrata</i>	164	12	1,2
	<i>Polydora caeca</i>	1	1	1
	<i>Polydora flava</i>	26	10	1,2,4
	<i>Polydora</i> sp.	2	2	1
	<i>Prionospio caspersi</i>	73	8	1,2,4
	<i>Prionospio cirrifera</i>	47	10	1,2
	<i>Prionospio malmgreni</i>	149	16	1,2,4
	<i>Prionospio</i> sp.	3	1	2
	<i>Prionospio steenstrupi</i>	4	2	2
	<i>Pseudopolydora antennata</i>	2	2	1,2
	<i>Scoelelepis cantabra</i>	1	1	2
	<i>Scoelelepis tridentata</i>	3	2	2,4
	<i>Spio decoratus</i>	2	1	2
	<i>Spio filicornis</i>	5	3	1,2,4
	<i>Spio multioculata</i>	14	4	1,4
	<i>Spiophanes bombyx</i>	3	2	1,4
	<i>Spiophanes kroyeri</i>	203	25	1,2,3
	Spionidae indet.	10	5	1,2
Sternaspididae	<i>Sternaspis scutata</i>	197	22	1,2,3

Family	Species	Tot. abund.	Frequency	Area
Syllidae	<i>Syllis armillaris</i>	3	3	2,4
	<i>Syllis cornuta</i>	15	5	1,2
	<i>Syllis</i> sp.	2	2	1,2
Terebellidae	<i>Amphitrite cirrata</i>	3	2	1
	<i>Amphitrite edwardsi</i>	2	1	1
	<i>Amphitrite</i> sp.	16	3	2
	<i>Lanice conchylega</i>	23	9	1,2,3
	<i>Pista cristata</i>	27	8	1,2
	<i>Polycirrus</i> sp.	11	5	2
	<i>Streblosoma bairdi</i>	4	3	2
	Terebellidae indet.	17	6	1,2
Trichobranchiidae	<i>Terebellides stroemi</i>	36	16	1,2,3
	<i>Trichobranchus glacialis</i>	1	1	2

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## THE FAUNA OF EPIKARST – COPEPODA (CRUSTACEA) IN PERCOLATION WATER OF KARST CAVES IN SLOVENIA

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### ABSTRACT

*Special attention was given to the stygobiotic species of copepods (Crustacea); their habitat is above the cave but under the surface in the so-called epikarst zone. Diversity dynamics of Copepoda were studied in six karst caves. In some caves (Postojnska jama, Pivka jama, Črna jama), samples were collected once per week. In the other three caves (Škocjanske jame, Dimnice, Županova jama), we sampled trickles once a month during 2000 and 2001. In total, 37 species were collected in the caves. From this habitat, 11 species new to science were recognized. New species living there are particularly restricted in distribution to one or few trickles of water dripping from the ceiling. The results of the faunistic research indicate that biodiversity of Copepoda in epikarst is very high on the local scale as well as over a wider area.*

**Key words:** caves, unsaturated zone, percolation water, Copepoda, Slovenia

## FAUNA DI COPEPODI (CRUSTACEA) EPICARSICI IN ACQUE DI PERCOLAZIONE DI GROTTA CARSICHE IN SLOVENIA

### SINTESI

*Particolare attenzione è stata rivolta alle specie stigobie di copepodi (Crustacea), che abitano gli habitat sopra le grotte ma sotto la superficie, quindi dell'area epicarsica. La dinamica di diversità dei copepodi è stata studiata in sei grotte carsiche. In alcune grotte (Grotte di Postumia, Grotta di Pivka e Grotta Nera) i campioni sono stati raccolti settimanalmente. Nelle restanti (Grotta di San Canziano, Dimnice e Grotta di Župan), i campionamenti sono stati effettuati mensilmente, negli anni 2000 e 2001. In totale sono stati raccolti 37 taxa nelle grotte. In tale habitat sono state trovate 11 nuove specie per la scienza. Tali specie hanno una distribuzione ristretta ad uno o pochi gocciolamenti d'acqua dal soffitto. I risultati della presente ricerca faunistica indicano un'alta biodiversità dei copepodi epicarsici sia su scala locale, sia considerando un'area più vasta.*

**Parole chiave:** grotte, zona insatura, acqua di percolazione, Copepoda, Slovenia

## INTRODUCTION

Karst is a special type of landscape, formed through dissolution of soluble rocks, including limestone and dolomite. The karst of Slovenia, with 43% of its territory consisting of carbonate rocks, is of great practical interest. Hypogean habitats constitute quite a significant part of nature in Slovenia, which has by far the richest aquatic hypogean fauna in the world (Sket, 1996). To understand the rarity of the organisms and the fragility of their habitats, we have to learn more about karst species, their ecosystems, and their sensitivity to environmental contamination.

The subterranean environment all over the world is inhabited by numerous taxa of Copepoda (Crustacea), and many of them are endemics. In Slovenia, 107 taxa of Copepoda have been recorded to date and about one third of these are stygobionts. At present, there are 15 endemics and all but one of them are stygobionts. All but one belong to the order of Harpacticoida (Brancelj, 1996).

The biodiversity and ecology of copepods in percolation water have rarely been systematically studied. Many species in the group of Copepoda are rarely found in streams, but are found in seeps and drip pools, although their existence in any particular set of seeps or pools is often quite ephemeral (Culver *et al.*, 1994). The primary habitat of these species is almost certainly the subcutaneous zone, i.e. epikarst (Holsinger, 1994). Due to the high level of endemism, the future research on the underground fauna should be carried out principally in the direction of fauna-related research. This should encompass the habitats that have remained unexplored, and these are particularly percolation waters.

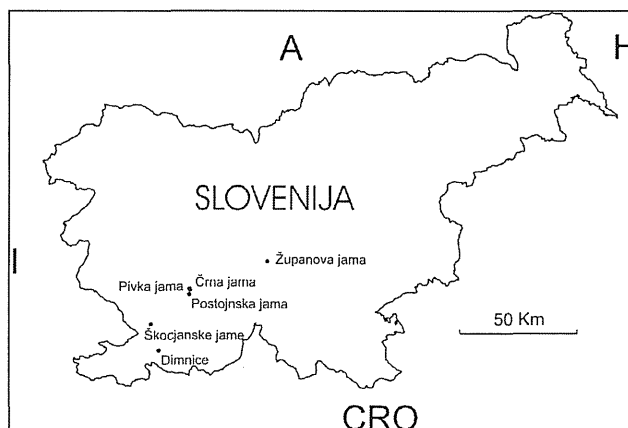
In 2000 and 2001, some intensive studies of micro-distribution and diversity dynamics of copepods were carried out in trickles and pools of percolation water in several cave systems in Slovenia. The working hypothesis was based upon the ecological, hydrogeological and chemical explorations of the karst unsaturated zone with an emphasis on the ecology of the copepod fauna in the percolation water. We focused on the following two main questions. First, whether there are, and what are, the causes of the biological differences in the epikarst evaluated from the differences between trickles, pools and environmental factors. Second, whether there are differences of fauna between caves in different geographical areas.

## MATERIAL AND METHODS

The six studied caves are situated in southern and southwestern Slovenia (Fig. 1). For a description of the study area, see Pipan & Brancelj (2001). We dealt with the epikarst fauna, which has been until recently an almost completely unknown segment of life within the

karst underground. In hydrological division of the karst underground, the epikarst constitutes the stratum, which is the closest to the surface but remains inaccessible, if standard research methods are to be used. The epikarst fauna has thus been explored indirectly, by taking samples of the percolated water and cave pools filled with such water. The pools in the fossil parts of the caves are filled up by water, which seeps down the walls or drips directly from the ceiling. With such a selection of pools we will avoid the influence of phreatic groundwater or hypogean rivers on the composition of the fauna.

In the caves of Postojnska jama, Pivka jama and Črna jama we sampled water trickles once per week for one year. In the other three caves, samples were collected once a month during 2000 and 2001. Samples of fauna as well as samples for water quality analyses were collected from the container. During the period of a single week or month, the water from trickles was directed through a funnel into 0.25 l plastic containers. On two sides, the containers had holes covered with a net (mesh size 60 µm) to retain animals in the container. The content of these plastic containers was fixed with 4 % final solution of formaldehyde in the field and stored for further processing. In the laboratory we separated the organisms by means of stereomicroscope at 40x magnification and stored them in 70% ethanol. Further processing and identification of the organisms was performed under a compound microscope. Samples from pools were collected separately into plastic containers by means of adapted suction pump. We pumped various quantities of the pool water at different sampling points and filtered it through a 60 µm net. The samples were then processed in the same way as those from the trickles. Each water trickle or pool filled with water was treated separately.



**Fig. 1: Geographical location of the research caves in Slovenia.**

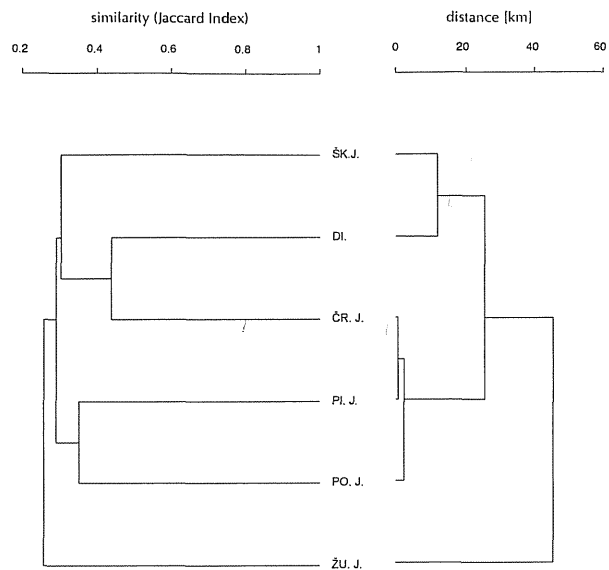
**Sl. 1: Geografska lega raziskovanih jam v Sloveniji.**

# RESULTS

In six karst caves, a systematic survey of two different types of habitats, trickles, and pools of percolation water was carried out. From seeps and drip pools we collected 37 species (Tab. 1). The most numerous were specimens of *Speocyclops infernus*, *Moraria poppei*, *Morariopsis scotenophila*, *Elaphoidella cvetkae*, *Bryocamptus balcanicus* and specimens of the genus *Parastenocaris*. Ten species belong to a group of troglophilous or eutroglophilous taxa, which are frequently also found in subterranean environment. The other 27 species are stygobiotic. Eleven species (from the genera *Bryocamptus*, *Elaphoidella*, *Maraenobiotus*, *Moraria*, *Nitocrella*, *Parastenocaris* and perhaps *Stygepactophanes*) were recognized as new to science and have to be studied in detail. It seems that they are obligate epikarst species.

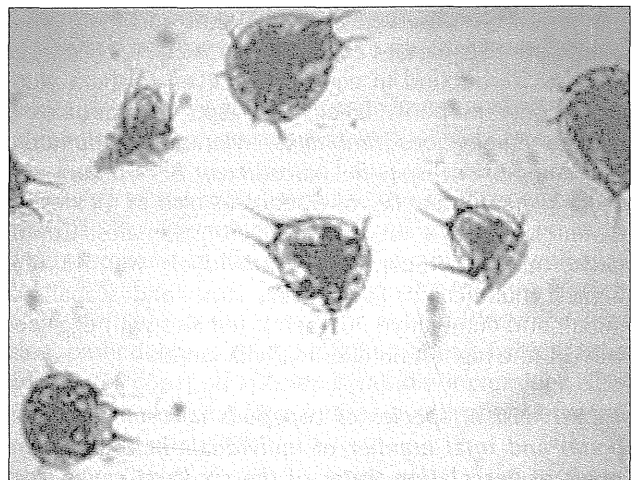
Results of the correlation analyses (using the Spearman correlation coefficient: Davis, 1973) and the non-parametric version of one way ANOVA (using the Kruskal-Wallis Test: Blejcek, 1976) indicate that there is no correlation between thickness of the cave ceiling, temperature and discharge on the one hand and the number of specimens on the other ( $p > 0.05$ ). The precipitation shows highly positive co-variation with the discharge and with the number of specimens in two caves. Physical parameters for each cave are summarized in Table 2. The copepod abundance in different kinds of pools was not correlated with the amount of pumped water. For more precise conclusions about correlation between pool typology or amount of filtered water and the number of specimens, a higher number of samples collected in shorter intervals should be analysed. New data can be obtained from further investigations in trickles of percolation water.

From the geographical point of view, there is no correlation ( $r = -0.38$ ,  $p = 0.31$ ) between the distance apart of the caves and the similarity of the fauna (using the Pearson correlation coefficient ( $r$ )). The highest similarity expressed as a ratio of the species in common between two locations and the sum of taxa of both locations (using the Jaccard similarity coefficient ( $S_j$ )) was between the caves of Dimnice and Črna jama ( $S_j = 0.44$ ), which are approximately 29 km apart (Fig. 2). In caves that belong to the same cave system (Postojnska jama, Pivka jama, Črna jama) and are 3 km apart, the similarity was lower and quite similar ( $S_j = 0.33 - 0.37$ ). This fact is not unexpected due to the same geographical and geological situation and the same influence of external environmental factors. The lowest similarity was between the caves of Škocjanske jame and Dimnice ( $S_j = 0.21$ ) and Škocjanske jame and Županova jama ( $S_j = 0.22$ ). Between the most distant caves, i.e. Dimnice and Županova jama that are about 61 km apart, the similarity was 0.27.



**Fig. 2:** Dendrogram constructed by data on similarity of copepod community and geographical distance between caves (UPGMA method, standardized on the Jaccard similarity coefficient). The abbreviations are: ČR.J. = Črna jama, DI. = Dimnice, ŠK.J. = Škocjanske jame, PO.J. = Postojnska jama, PI.J. = Pivka jama, ŽU.J. = Županova jama.

**Sl. 2:** Primerjava podobnosti združb ceponožcev in geografskih razdalj med jamami v dendrogramu podobnosti po metodi UPGMA (uporabljen je Jaccardov koeficient podobnosti). Okrajšave: ČR.J. = Črna jama, DI. = Dimnice, ŠK.J. = Škocjanske jame, PO.J. = Postojnska jama, PI.J. = Pivka jama, ŽU.J. = Županova jama.



**Fig. 3:** The life cycle of free-living copepods includes up to six naupliar and six copepodit stages prior to the adult.

**Sl. 3:** Prosto živeči ceponožci imajo šest navplijskih in šest copepoditnih stadijev.



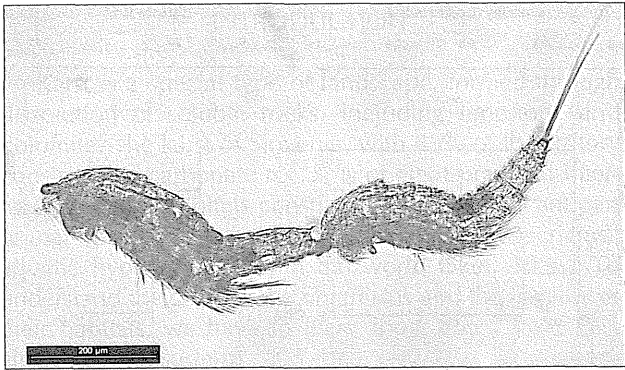


Fig. 4: Pre-copulating individuals of *Bryocamptus zschokkei*.  
Sl. 4: Paritveni par vrste *Bryocamptus zschokkei*.

Nauplia (Fig. 3) were present in all samples, although they were more abundant in samples from trickles than in samples from pools. The exceptions were trickles in Postojnska jama, where they were completely absent.

Sex ratio varied, but in most samples females were predominant. Males dominated only in the samples from trickles in Škocjanske jame. Juveniles constituted from 0.5% to 20% of the population.

Precopulatory mating individuals (Fig. 4) were found in five caves (except in Postojnska jama) in six species. They were predominant in samples from pools. In trickles and in pools we found copula in *Bryocamptus balcanicus* and *Maraenobiotus* cf. *brucei*. Pre-copulating individuals of *Bryocamptus dacicus*, *B. typhlops*, *B. zschokkei* and *B. pyrenaicus* were collected only from pools. Precopulatory mating individuals were found only during the winter (from September to February). Egg sacs were observed also in August and then every month from September 2000 till March 2001. Ovigerous females were found in eight taxa. Seven of them were found only in pools (*Diacyclops* sp. (*languidoides* – group), *Paracyclops fimbriatus*, *Morariopsis dumonti*, *Bryocamptus* n. sp., *B. balcanicus*, *B. typhlops*, *B. zschokkei*) and females of *B. dacicus* also in trickles. In Dimnice cave, we found no ovigerous females. Cumulative number of copulatory individuals was 43 (the highest number in Škocjanske jame and Županova jama), and cumulative number of females with egg sacs was 34 (the highest number in Pivka jama).

Tab. 1: List of species of copepods (Crustacea: Copepoda) and total number of individuals in trickles and pools of percolation water of the six karst caves (species presumed to be new to science are marked with asterisk \*).  
Tab. 1: Seznam vrst ceponožnih rakov (Crustacea: Copepoda) in skupno število osebkov v prenikajoči in prenikli vodi šestih kraških jam (za znanost nove vrste so označene z zvezdico \*).

	stygobionts / stigobionti	trickles / curki	pools / luže
CYCLOPOIDA			
1. <i>Acanthocyclops kieferi</i> (Chappuis, 1925)	x		17
2. <i>Diacyclops</i> sp. ( <i>languidoides</i> –group) (Lilljeborg, 1901)	x	2	108
3. <i>Diacyclops languidus</i> (Sars, 1863)			1
4. <i>Megacyclops viridis</i> (Jurine, 1820)			11
5. <i>Paracyclops fimbriatus</i> (Fischer, 1853)			8
6. <i>Speocyclops infernus</i> (Kiefer, 1930)	x	141	794
HARPACTICOIDA			
7. <i>Attheyella crassa</i> (Sars, 1862)			1
8. <i>Bryocamptus balcanicus</i> (Kiefer 1933)	x	94	174
9. <i>Bryocamptus borus</i> Karanovic & Bobic, 1998	x		6
10. <i>Bryocamptus dacicus</i> (Chappuis 1923)		68	156
11. <i>Bryocamptus pygmaeus</i> (Sars, 1862)	x		4
12. <i>Bryocamptus pyrenaicus</i> (Chappuis, 1923)	x	8	37
13. <i>Bryocamptus typhlops</i> (Mrazek, 1893)	x		81
14. <i>Bryocamptus zschokkei</i> (Schmeil, 1893)			82
15. <i>Bryocamptus</i> sp.*	x	1	14
16. <i>Elaphoidella cvetkae</i> Petkovski, 1983	x	98	6
17. <i>Elaphoidella kieferi</i> Petkovski & Brancelj, 1985	x	5	1
18. <i>Elaphoidella stammeri</i> Chappuis, 1936	x	10	
19. <i>Elaphoidella</i> sp. 1*	x	2	8
20. <i>Elaphoidella</i> sp. 2*	x	3	
21. <i>Epactophanes richardi</i> (Mrazek, 1893)			43
22. <i>Maraenobiotus</i> cf. <i>brucei</i> *	x	96	68
23. <i>Moraria poppei</i> (Mrazek, 1893)		5	754
24. <i>Moraria stankovitchi</i> Chappuis, 1924	x	1	
25. <i>Moraria varica</i> (Graeter, 1911)		10	5
26. <i>Moraria</i> sp. A*	x	4	
27. <i>Moraria</i> sp. B*	x	1	
28. <i>Morariopsis dumonti</i> Brancelj, 2000	x	3	64
29. <i>Morariopsis scotenophila</i> (Kiefer 1930)	x	2	247
30. <i>Nitocrella</i> sp.*	x	5	
31. <i>Parastenocaris nollu alpina</i> (Kiefer, 1938)	x	121	4
32. <i>Parastenocaris</i> cf. <i>andreji</i> *	x	1	1
33. <i>Parastenocaris</i> sp. 1*	x	5	1
34. <i>Parastenocaris</i> sp. 2*	x	160	11
35. <i>Parastenocaris</i> sp. 3*	x	7	
36. <i>Phyllognathopus viguieri</i> (Maupas, 1892)		1	4
37. <i>Stygepactophanes</i> (?) sp.*	x	10	

**Tab. 2: Minimum and maximum values for some physical parameters, measured in six caves between April 2000 and March 2001.**

**Tab. 2: Najnižje in najvišje vrednosti nekaterih fizikalnih podatkov v šestih jamah, merjene od aprila 2000 do marca 2001.**

Parameter/Cave Podatek/Jama (min-max)	POSTOJNSKA JAMA	PIVKA JAMA	ČRNA JAMA	ŠKOCJANSKE JAME	DIMNICE	ŽUPANOVA JAMA
Thickness of the cave ceiling / debelina jamskega stropa [m]	30-110	50-70	30-65	60-110	10-70	15-50
Average temperature / povprečna temperatura [°C]	8.6-9.4	5.3-9.0	4.5-7.0	9.5-12.0	4.1-9.3	6.1-9.2
Average discharge / povprečen pretok [ml min <sup>-1</sup> ]	1.9-22.0	1.7-202.0	8.0-59.0	18.0-182.0	3.2-75.0	4.1-33.0
Annual precipitation / letne padavine [mm]	1827	1827	1827	1548	2019	1577

## DISCUSSION

The high level of endemism, as evident from the literature published to date, and insufficient knowledge regarding the distribution of taxa inhabiting the unsaturated karst zone, were two main reasons for our decision to focus on the problems and issues related to the distribution and the ecology of the fauna in the unsaturated epikarst zone. According to rather few explorations, the major part of the fauna in percolation water consists of copepods (Galassi, 2001). During our exploration, we restricted ourselves to the community of copepods in the karst fissured system in caves. The intensive research on Copepoda in six caves in Slovenia indicated a high number of taxa, whose primary habitat are cracks and crevices filled with water in the epikarst zone. In total, 37 species were collected in six horizontal caves. Eleven species new to science were recognized. New species living there are particularly restricted in distribution to one or few trickles of dripping water. Ten species, which are frequently found in subterranean environment but transported from their epigean habitats, could be designated as ubiquitous. The rest of the species, i.e. 27 of them, are stygobiotic, and fifteen are endemic to Slovenia. One species, *Bryocamptus borus*, is new to the Slovenian fauna. Males of *Morariopsis scotophilus* were found for the first time.

Between 11 and 17 different species of copepods were found per cave regardless of its length. From 37 species, only two, *Speocyclops infernus* and the new species *Parastenocaris* sp., were found in all six caves. The majority of species were found in one or two caves only. Sixteen species were found only at a single locality and eleven of these were stygobiotic.

The drip pools and seeps form a distinct habitat in the cave (Culver *et al.*, 1994). The intensive survey of the two types of habitats in six karst caves showed that the ratio of copepods in the trickles was different from that in the pools of percolation water. Paradoxically, the starting point for analysis of the copepod community

structure is not heterogeneity between types of habitats (trickle – pool), but self-similarity. It is important that in both types of habitats we found mostly the same groups of specimens, which differed only in the frequency of their occurrence. We established a similar species composition, which indicates that the real habitat of the stygobiotic species of copepods is above the cave but under the surface, in the epikarst zone.

The high number of specimens found in the cave and the low number of specimens involved in reproduction suggest that the water bodies sampled in the cave are probably not the breeding site for most species. This supports the idea of Brancelj (2002) who proposed that the habitat where they breed, at least for some of them, is the space beneath the soil layer. They can penetrate deeper into the rocks through small crevices, filled by water.

The results and findings of the research constitute a fundamental contribution to the understanding of distribution patterns of stygobiont copepods in the epikarst zone. Results of such studies are of general interest and value. This information helps us to better understand the interactions of organisms within the karst ecosystem. The biodiversity of epikarst fauna will be at the same time used to study and evaluate the impacts of human activities on the subterranean environment. The most urgent problem in the karst area is pollution with percolation water, which usually originates from the surface pollution. Due to the numerous newly discovered species, particularly within the subterranean habitats, the number of copepod species is rapidly increasing. New data can be obtained from further investigations of fauna in seeps and drip pools.

## ACKNOWLEDGMENTS

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FAVNA EPIKRASA – COPEPODA (CRUSTACEA) V PRENIKAJOČI VODI  
KRAŠKIH JAM V SLOVENIJI

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## POVZETEK

V članku so podani kvalitativni in kvantitativni podatki o favni ceponožnih rakov v curkih prenikajoče vode in v lužah, ki jih ta polni. Ceponožni raki so najbogateje zastopana živalska skupina v epikrasu. Nezasičena kraška cona je s standardnimi raziskovalnimi metodami nedostopna, zato je bilo vzorčevanje epikraške vodne favne posredno, z vzorčenjem prenikajoče vode. V šestih kraških jamah je bilo opravljeno sistematično vzorčenje v curkih prenikajoče vode in lužah, ki jih ti curki napajajo. Curki prenikajoče vode so se stekali v lijak, od koder je stekla voda v plastenko z dvema odprtinama, zamreženima z gosto mlinarsko svilo z odprtinami 60x60 µm. Plastenka je bila v večji posodi z vgrajeno odtočno cevjo. Voda iz plastenke je odtekala skozi mrežico v posodo z odtokom, živali pa so ostale ujete v plastenki. Vzorci so bili fiksirani z dodatkom 37% formalina do končne koncentracije okrog 4% in shranjeni za nadaljnjo obdelavo v laboratoriju. Voda in usedlina v lužah je bila posesana s pomočjo prirejene sesalne črpalke ter precejena skozi mrežico z odprtinami 60x60 µm. Najdenih je bilo 37 vrst ceponožnih rakov, med njimi 27 stigobionskih. Vrsta *Bryocamptus borus* je bila prvič ugotovljena v Sloveniji. Prvič so bili najdeni samci vrste *Morariopsis scotenophila*. Ugotovljenih je bilo še 11 vrst iz 7 rodov, novih za znanost. Za 10 vrst je znano, da v jame zaidejo naključno s curki prenikajoče vode in da so v površinskih in podzemeljskih vodah pogoste. Osebkami drugih vrst, ki so bili najdeni v posameznih jamah ali na posameznih vzorčevalnih mestih v jami, so stigobionti. Petnajst med njimi je endemitov, omejenih le na ozemlje Slovenije. V posamezni jami je bilo med 11 in 17 vrst ceponožcev. Pojavljanje in številčnost vrst ter vrstna sestava v prenikajoči vodi niso odvisni od velikosti jame. Ugotovljena je bila velika vrstna raznolikost med jamami. Samo *Specocyclops infernus* in nova vrsta *Parastenocaris* sp. 2 sta bili v vseh šestih jamah. Šestnajst vrst je bilo najdenih le v eni jami, od tega 11 stigobiontov. V curkih in lužah s prenikajočo vodo je maloštevilna, a vrstno bogata favna ceponožcev. Podobnost kopepodnih združb v jamah ni v soodvisnem razmerju z geografsko oddaljenostjo med jamami, z debelino stropa, s temperaturo in pretokom, ampak morda z obstojem podobnih mikrohabitatov v epikraški coni. Za večino curkov je soodvisnost med padavinami in pretokom statistično značilna. Številčnost kopepodov v različnih tipih luž ni sorazmerna s količino prefiltrirane vode. Zaradi visoke stopnje ekološke specializacije kopepodov iz epikraške cone bi lahko bile mnoge vrste uporabne kot bioindikatorji pri ocenjevanju vplivov človekove dejavnosti na podzemeljske habitate.

**Ključne besede:** jame, nezasičena cona, prenikajoča voda, Copepoda, Slovenija

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## HETEROPTERA OF SLOVENIA, I: DIPSOCOROMORPHA, NEPOMORPHA, GERROMORPHA AND LEPTOPODOMORPHA

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### ABSTRACT

*Heteroptera of the infraorders Dipsocoromorpha, Nepomorpha, Gerromorpha and Leptopodomorpha living in Slovenia are listed. Literature data are summarized. The material in the collections of the Slovenian Museum of Natural History had been re-examined and all known data on the localities and dates are presented. Notonecta meridionalis, Saldula palustris, Salda adriatica and Patapius spinosus are reported from Slovenia for the first time. The type locality of Velia saulii is clarified.*

**Key words:** Heteroptera, Dipsocoromorpha, Nepomorpha, Gerromorpha, Leptopodomorpha, Slovenia, fauna

## HETEROPTERA IN SLOVENIA, I.: DIPSOCOROMORPHA, NEPOMORPHA, GERROMORPHA E LEPTOPODOMORPHA

### SINTESI

*L'articolo elenca gli eterotteri (Heteroptera) degli infraordini Dipsocoromorpha, Nepomorpha, Gerromorpha e Leptopodomorpha viventi in Slovenia e offre un sommario dei dati di letteratura. Il materiale contenuto nelle collezioni del Museo di Storia Naturale della Slovenia è stato riesaminato e l'autore presenta tutti i dati disponibili. Notonecta meridionalis, Saldula palustris, Salda adriatica e Patapius spinosus sono specie riportate per la prima volta in Slovenia. Viene inoltre fornito un chiarimento in merito alla località tipo per Velia saulii.*

**Parole chiave:** Heteroptera, Dipsocoromorpha, Nepomorpha, Gerromorpha, Leptopodomorpha, Slovenia, fauna

## INTRODUCTION

Two checklists of the Heteroptera of Slovenia were published by Andrej and Matija Gogala (Gogala & Gogala, 1986, 1989), but several literature data were not included at all. The localities of most of the findings were not published, but only 10 x 10 km squares of the UTM grid. The Catalogue of the Heteroptera fauna of Yugoslav countries (Protić, 1998) summarized the published records. Nature conservation efforts need exact localities, with all possible data. The present work is the first in a series planned to fulfil the needs. It contains literature data and lists the material from the collections of the Slovenian Museum of Natural History and some other collections. The material had been re-examined and many misidentifications corrected.

*Notonecta meridionalis*, *Saldula palustris*, *Salda adriatica* and *Patapius spinosus* are reported from Slovenia for the first time. *Micronecta minutissima*, *Notonecta obliqua* and *Saldula pilosella pilosella* are omitted from the list of Slovenian Heteroptera due to misidentifications.

Some species were listed for Slovenia in the Catalogue of the Heteroptera of the Palaearctic Region (Aukema & Rieger, 1995), but I have been unable to find the original reports. I suppose the confusion with Slovakia is possible. These species are listed, but with a question mark. In the same catalogue, the type locality of *Velia saulii* was wrongly attributed to Croatia. The locality Istria, Val Recca, is the Reka valley in Slovenia. The locality Lanišče (Istria) in Gogala & Moder (1960), on the other hand, is situated in the Croatian part of Istria.

All water and shore bugs, the matter of this contribution, are threatened due to water pollution, regulations of streams and rivers and drainage of marshes and pools. Particularly vulnerable are species living only in a single locality in Slovenia. Any development, construction or change in land use in their habitats could cause the extinction of the species in the country.

## RESULTS

## List of species

## DIPSOCOROMORPHA

## Dipsocoridae

***Cryptostemma alienum*** Herrich-Schaeffer, 1835 (Fig. 1)

Gogala & Gogala, 1987: Dolina Dragonje

Gogala & Gogala, 1989; Gogala, 1992

Unpublished records:

Istra: Boršt, r. Dragonja, VL03, 3. 5. 1986, A. & M. Gogala leg.

Istra: Koštabona, r. Dragonja, VL03, 7. 8. 1986, A. & M. Gogala leg.

Idrija, Krekovše, r. Belca, VL19, 28. 6. 1988, M. Gogala leg.

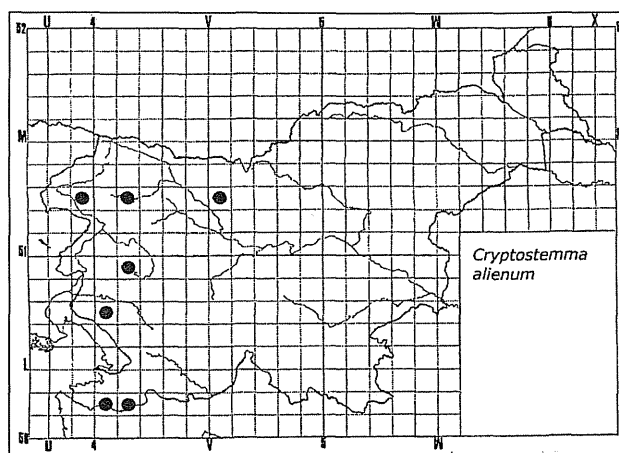
Bohinj: Stara Fužina, Bohinjsko jezero, VM12, 10. 7. 1988, A. & M. Gogala leg.

Julijske Alpe: Krnska jezera, UM92, 31. 7. 1988, A. & M. Gogala leg.

Kranj, Bobovek, Milka, VM52, 24. 4. 1989, S. Brelih leg.

Istra: Sočerga, Mlini, VL13, 1. 8. 1990, A. & M. Gogala leg.

Braniška dolina: Sp. Branica, Čipnje, r. Branica, VL07, 25. 5. 1997, A. & M. Gogala leg.



**Fig. 1: The distribution of *Cryptostemma alienum* in Slovenia.**

**Sl. 1: Razširjenost vrste *Cryptostemma alienum* v Sloveniji.**

## NEPOMORPHA

## Nepidae

***Nepa cinerea*** Linnaeus, 1758

*N. rubra* Linnaeus, 1758

Gogala & Moder, 1960: Ljubljana, 8. – 5., Staudacher & Gogala leg.; Preska, 28. 1. 1955, M. Gogala leg.;

Drava, 8. 10. 1955, M. Gogala leg.; Cerknica, M. Gogala leg.; Sečovelje, 21. 4. 1955, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Ljubljana: Rožnik, VM50, 9. 9. 1953, M. Gogala leg.

Medvode, Pirniče, VM51, 13. 2. 1977, A. & M. Gogala leg.

Vipavska dolina: Renče, UL98, 22. 7. 1980, A. & M. Gogala leg.

Planinsko polje: Laze, VL47, 11. 6. 1982, A. & M. Gogala leg.

Ljubljansko barje: Log, Lukovica, VL59, 21. 5. 1983, A. & M. Gogala leg.

Maribor: Trije ribniki, WM55, 5. 10. 1980, D. Devetak leg.

Kras: Komen, Brestovica, UL97, 2. 5. 1990, A. & M. Gogala leg.  
 Ljubljansko barje: Vrhnika, VL49, 30. 9. 1998, T. Trilar leg.  
 Istra: Trebeše, r. Stranica, VL13, 14. 8. 2002, A. Gogala leg.  
 Istra: Fiesa, UL94, 15. 8. 1996, A. Kapla leg. et coll.  
 Prekmurje: Ledavsko jezero, WM87, 9. 4. 1997, B. Drovenik leg., coll. S. Brelih  
 Ilirska Bistrica, mrtvica pri Lesonitu, VL44, 4. 8. 2002, S. Polak leg. (larvae)

***Ranatra linearis*** (Linnaeus, 1758)

Gogala & Moder, 1960: Ljubljana, 7. – 11., Staudacher & Gogala leg.; Drava, 8. 10. 1955, M. Gogala leg.; ob Rižani, 20. 4. 1959, M. Gogala leg.  
 Gogala & Gogala, 1986; Gogala & Gogala, 1989  
 Unpublished records:  
 Slovenske gorice: ribnik Komarnik, WM65, 20. 6. 1986, D. Devetak leg.  
 Kras: Komen, Brestovica, UL97, 2. 5. 1990, A. & M. Gogala leg.  
 Prekmurje: Ledavsko jezero, WM87, 18. 7. 1995  
 Ilirska Bistrica, mrtvica pri Lesonitu, VL44, 4. 8. 2002, S. Polak leg. (larvae)

Corixidae

***Micronecta scholtzi*** (Fieber, 1860)

*M. meridionalis* (A. Costa, 1862)  
 Gogala & Gogala, 1989  
 Unpublished records:  
 Prekmurje: Mursko Središče, slov. stran r. Mure, XM15, 6. 7. 1980, A. & M. Gogala leg.  
 Prekmurje: Petišovci, XM15, 13. 6. 1987, A. & M. Gogala leg.  
 Prekmurje: Dolenja Bistrica, XM05, 23. 5. 1992, A. & M. Gogala leg.

***Micronecta griseola*** Horváth, 1899

Gogala, 1991:  
 Cerkniško polje: Cerknica, r. Cerkniščica, VL57, 24. 7. 1986, C. Krušnik leg.

***Micronecta poweri*** (Douglas & Scott, 1869)

? Jansson, 1995: Slovenia

***Cymatia coleoptrata*** (Fabricius, 1777)

Gogala & Gogala, 1986  
 Unpublished records:  
 Ljubljansko barje: Ig, Dobravica, Draga, VL68, 22. 3. 1980, A. & M. Gogala leg.  
 Prekmurje: Petišovci, XM15, 30. 4. 1983, A. & M. Gogala leg.

***Arctocoris carinata*** (Sahlberg, 1819)

Gogala & Moder, 1960: pl. Viševnik, 10. 8. 1958, M. Gogala leg.  
 Gogala & Gogala, 1989; Gogala, 1992  
 Unpublished records:  
 Julijske Alpe: Krnska jezera, UM92, 31. 7. 1988, A. & M. Gogala leg.  
 Julijske Alpe: Triglavski Nacionalni Park: Zeleno jezero, VM03, 5. 9. 1994, A. Brancelj leg.  
 Julijske Alpe: Triglavski Nacionalni Park: Črno jezero, VM03, 4. 9. 1994, A. Brancelj leg.

***Corixa affinis*** Leach, 1817

Gogala & Moder, 1960: Ljubljana, 5. 8. 1954, M. Gogala leg.

***Corixa punctata*** (Illiger, 1807)

Gogala & Moder, 1960: Ljubljana, 9. – 3., M. Gogala leg.  
 Gogala & Gogala, 1986  
 Unpublished records:  
 Kras: Petrinje, VL14, 15. 4. 1979, A. & M. Gogala leg.  
 Kočevje, VL85, 20. – 28. 7. 1979  
 Ljubljana: Koseze, VM50, 18. 9. 1954, M. Gogala leg.  
 Hrastnik, Draga, WM01, 28. 9. 1999, A. Kapla leg.  
 Kras: Hruševica, VL07, 3. 2. 2002, A. & M. Gogala leg.

***Hesperocoris linnaei*** (Fieber, 1848)

? Jansson, 1995: Slovenia

***Hesperocoris parallela*** (Fieber, 1860)

? Jansson, 1995: Slovenia

***Hesperocoris sahlbergi*** (Fieber, 1848)

Gogala & Gogala, 1986  
 Unpublished records:  
 Prekmurje: Bukovniško jezero, XM07, 30. 4. 1983, A. & M. Gogala leg.  
 Ljubljansko barje: Grmez, VL69, 8. 8. 1999, S. Gomboc & D. Kofol leg. et coll.

***Paracoris concinna*** (Fieber, 1848)

? Jansson, 1995: Slovenia

***Sigara hellensii*** (Sahlberg, 1819)

Gogala & Gogala, 1989  
 Unpublished record:  
 Pomurje: Veržej, WM96, 13. 6. 1987, A. & M. Gogala leg.

***Sigara nigrolineata*** (Fieber, 1848)

Montandon, 1886: Gorica  
 Gogala & Moder, 1960: Ljubljana, 13. 3. 1954, M. Gogala leg.  
 Gogala & Gogala, 1986; Gogala & Gogala, 1989  
 Unpublished records:



Ljubljansko barje: Log, Lukovica, VL59, 14. 4. 1979, 21. 4. 1979, A. & M. Gogala leg.

Radovljica, VM33, 4. 3. 1979, A. & M. Gogala leg.

Ljubljansko barje: Bevke, VL59, 20. 2. 1977, A. & M. Gogala leg.

Ljubljana, Dolsko, VM70, 12. 4. 1980, A. & M. Gogala leg.

Ljubljana, Mestni log, VL59, 1. 5. 1980, A. & M. Gogala leg.

Julijske Alpe: Nemški Rovt, VM22, 15. 8. 1981, A. & M. Gogala leg.

Velike Lašče, Podstrmec, VL67, 4. 6. 1981, S. Brelih leg.

Julijske Alpe: Krnska jezera, UM92, 31. 7. 1988, A. & M. Gogala leg.

Goriška Brda: Dobrovo, UL89, 4. 5. 1990, S. Brelih leg.

Kras: Brje pri Komnu, VL07, 22. 9. 2001, M. Gogala leg.

Kočevje, Gotenica, 600 m, VL85, 4. 7. 1997, S. Brelih leg. et coll.

Ljubljansko barje: Preserje, Ponikve, VL58, 8. 8. 2003, A. Gogala leg.

***Sigara limitata*** (Fieber, 1848)

? Jansson, 1995: Slovenia

***Sigara semistriata*** (Fieber, 1848)

? Jansson, 1995: Slovenia

***Sigara striata*** (Linnaeus, 1758)

Gogala & Gogala, 1986

Unpublished record:

Kočevje, VL85, 28. 7. 1979, ZRC SAZU leg.

***Sigara distincta*** (Fieber, 1848)

? Jansson, 1995: Slovenia

***Sigara falleni*** (Fieber, 1848)

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Rakitna, VL58, 17. 2. 1980, A. & M. Gogala leg.

Ljubljansko barje: Ig, Dobravica, Draga, VL68, 22. 3. 1980, A. & M. Gogala leg.

Planinsko polje: Planina, Laze, VL47, 11. 5. 1986, A. & M. Gogala leg.

Cerkniško jezero: Dolenje Jezero, VL56, 24. 9. 1986, C. Krušnik leg.

Laibach (= Ljubljana), 2. 10. 1931, Staudacher leg.

Cerkniško jezero: Gorica, VL56, 29. 8. 2000, S. Brelih leg. et coll.

Cerkniško jezero: Zadnji kraj, VL56, 11. 8. 1994, S. Brelih leg. et coll.

***Sigara fossarum*** (Leach, 1817)

Gogala & Gogala, 1986

Unpublished records:

Ljubljansko barje: Notranje Gorice, VL59, 23. 4. 1978, A. & M. Gogala leg.

Radovljica, Lencovo, VM33, 28. 7. 1929, Staudacher leg.

***Sigara lateralis*** (Leach, 1817)

Montandon, 1886: Gorica

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Bela krajina: Damelj, WL13, 11. 7. 1974, M. Štangelj leg.

Prekmurje: Moravci, WM97, 30. 4. 1983, A. & M. Gogala leg.

Julijske Alpe: Krnska jezera, UM92, 31. 7. 1988, A. & M. Gogala leg.

Kras: Brje pri Komnu, VL07, 12. 4. 1992, A. & M. Gogala leg.

Kras: Hruševica, VL07, 3. 2. 2002, A. & M. Gogala leg.

**Naucoridae**

***Ilyocoris cimicoides*** (Linnaeus, 1758)

Montandon, 1886: Gorica

Gogala & Moder, 1960: Ljubljana, 4. – 10., Staudacher & M. Gogala leg.; Drava, 8. 10. 1955, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Protič, 1998: Gorica

Unpublished records:

Kras: Petrinje, VL14, 15. 4. 1979, A. & M. Gogala leg.

Prekmurje: Bukovniško jezero, XM07, 30. 4. 1983, A. & M. Gogala leg.

Prekmurje: Petišovci, XM15, 30. 4. 1983, 13. 6. 1987, A. & M. Gogala leg.

Ljubljansko barje: Bistra, VL48, 24. 6. 1983, A. & M. Gogala leg.

Ljubljansko barje: Ig, Dobravica, Draga, VL68, 4. 5. 1985, A. & M. Gogala leg.

Istra: Movraž, Movraška vala, VL13, 18. 2. 1990, A. & M. Gogala leg.

Kras: Brestovica pri Komnu, UL97, 2. 5. 1990, A. & M. Gogala leg.

Ilirska Bistrica, mrtvica pri Lesonitu, VL44, 4. 8. 2002, S. Polak leg.

Laško, Govce, WM11, 7. 4. 1996, A. Kapla leg. et coll.

Prekmurje: Ledavsko jezero, 220 m, WM87, 9. 4. 1997, S. Brelih leg. et coll.

Kras: Brestovica pri Povirju, Studence, VL16, 10. 3. 2001, photo A. Gogala.

**Aphelocheiridae**

***Aphelocheirus aestivalis*** (Fabricius, 1794)

Gogala & Gogala, 1986; Gogala, 1992: r. Krka (WL17, VL37), r. Vipava (UL98), r. Ledava (WM97), r. Mirna (WL29), r. Bloščica.

Unpublished records:

Kostanjevica, r. Krka, WL37, 3. 8. 1971.

Bloška planota: Vel. Bloke, r. Bloščica, VL57, 16. 2. 1989, I. Sivec leg.

## Notonectidae

***Notonecta glauca*** Linnaeus, 1758

Gogala & Moder, 1960: Ljubljana, 8. – 4., Staudacher & M. Gogala leg.; Drava, 2. 8. 1956, M. Gogala leg.; Cerknica, 26. 5. 1953, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Ljubljana, Podutik, VM50, 12. 11. 1978, A. & M. Gogala leg.

Ljubljansko barje: Ig, Dobravica, Draga, VL68, 22. 3. 1980, A. & M. Gogala leg.

Ljubljansko barje: Log, Lukovica, VL59, 10. 7. 1981, 30. 3. 1987, 12. 3. 1989, A. & M. Gogala leg.

Cerkniško jezero: Cerknica, Dolenje Jezero, VL56, 29. 6. 1983, A. & M. Gogala leg.

Ilirska Bistrica, mrtvica pri Lesonitu, VL44, 4. 8. 2002, S. Polak leg.

Ljubljansko barje: Ig, Matena, VL69, 27. 8. 2000, S. Brelj leg. et coll.

Kočevje, Gotenica, 600 m, VL85, 4. 7. 1997, S. Brelj leg. et coll.

Kranj, Bobovek, VM52, 26. 4. 1999, S. Brelj leg. et coll.

***Notonecta maculata*** Fabricius, 1794

Gogala & Moder, 1960: Strunjan, 19. 4. 1959, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Istra: Koper, Marezige, VL04, 4. 1974

Vipavska dolina: Ajdovščina, Planina, VL17, 25. 3. 1988, A. & M. Gogala leg.

Kras: Brje pri Komnu, VL07, 14. 5. 1989, A. & M. Gogala leg.

Istra: Trebeše, r. Stranica, VL13, 14. 8. 2002, A. Gogala leg.

Kras: Brestovica pri Povirju, Studence, VL16, 1. 3. 2003, A. Gogala leg.

Istra: Strunjan, Karbonar, UL94, 17. 5. 2003, A. & M. Gogala leg.

***Notonecta meridionalis*** Poisson, 1926

Unpublished records:

Prekmurje: Moravci, WM97, 30. 4. 1983, A. & M. Gogala leg.

Prekmurje: Turnišče, XM06, 30. 4. 1983, A. & M. Gogala leg.

Istra: Movraž, Movraška vala, VL13, 18. 2. 1990, A. & M. Gogala leg.

***Notonecta viridis*** Delcourt, 1909

Gogala & Moder, 1960: Ljubljana, 20. 1. 1954, 3. 10. 1954, M. Gogala leg.

Unpublished record:

Kras: Hruševica, VL07, 3. 2. 2002, A. & M. Gogala leg.

## Pleidae

***Plea minutissima*** Leach, 1817

*P. leachi* M'Gregor & Kirkaldy, 1899

Gogala & Moder, 1960: Ljubljana, 8. – 9., Staudacher & M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Ljubljansko barje: Matena, VL69, 24. 4. 1977, A. & M. Gogala leg.

Ljubljansko barje: Ig, Dobravica, Draga, VL68, 22. 3. 1980, A. & M. Gogala leg.

Prekmurje: Mursko Središče, slov. stran r. Mure, XM15, 6. 7. 1980, A. & M. Gogala leg.

Prekmurje: Petanjci, WM86, 29. 4. 1983, A. & M. Gogala leg.

Prekmurje: Bukovniško jezero, XM07, 30. 4. 1983, A. & M. Gogala leg.

Prekmurje: Petišovci, XM15, 30. 4. 1983, 13. 6. 1987, A. & M. Gogala leg.

Prekmurje: Goričko, Gornji Petrovci, WM98, 1. 5. 1983, A. & M. Gogala leg.

Kras: Brestovica pri Komnu, UL97, 2. 5. 1990, A. & M. Gogala leg.

Istra: Movraž, Movraška vala, VL13, 18. 5. 1990, A. & M. Gogala leg.

Prekmurje: Mala Polana, Črni log, XM06, 23. 5. 1992, A. & M. Gogala leg.

Prekmurje: Ledavsko jezero, WM87, 9. 4. 1997, S. Brelj leg.

## GERROMORPHA

## Mesoveliidae

***Mesovelia furcata*** Mulsant & Rey, 1852

Gogala & Moder, 1960: Ig, 9. 10. 1954, M. Gogala leg.

Gogala, 1996:

Prekmurje: Dolenja Bistrica, XM05, 23. 5. 1992, A. & M. Gogala leg.

## Hebridae

***Hebrus pusillus*** (Fallén, 1807)

Montandon, 1886: Gorica

Gogala & Gogala, 1987: Dolina Dragonje

Gogala & Gogala, 1989; Gogala, 1992

Unpublished records:

Istra: Koštabona, Škrline, r. Dragonja, VL03, 7. 8. 1986, A. & M. Gogala leg.

Istra: Sočerga, Mlini, VL13, 1. 8. 1990, A. & M. Gogala leg.

Istra: Trsek, r. Dragonja, VL03, 7. 7. 2000, A. Gogala leg.

Istra: Sirči, VL03, 21. 7. 1997, S. Brelj leg. et coll.

Rače, ribnik v gozdu, WM54, 12. 5. 1992, V. Furlan leg. et coll.

***Hebrus ruficeps*** Thomson, 1871

Gogala, 1992

Unpublished records:

Carniolia: Utik, VM50, 7. 1918, Stussiner leg.

Laibach (= Ljubljana), 30. 9. 1928, Staudacher leg.

Prekmurje: Muriša, 422 m, rob mrtvice, XM25, 5. 10. 2001, A. Pirnat leg.

Hydrometridae

***Hydrometra stagnorum*** (Linnaeus, 1758)

Gräffe, 1911: Gorica

Gogala &amp; Moder, 1960: Ljubljana, 6. 5. 1954, 5. 8. 1954, 12. 10. 1953, M. Gogala leg.; Črnuče, Brinje, 2. 4. 1954, 5. 7. 1954, M. Gogala leg.; Ptuj, 12. 10. 1954, M. Gogala leg.; Sečovelje, M. Gogala leg.; Portorož, Sv. Lucija, 21. 4. 1955, M. Gogala leg.

Gogala &amp; Gogala, 1986; Gogala &amp; Gogala, 1989

Unpublished records:

Laibach, Stadtwald (= Ljubljana, Mestni log), VL59, 19. 3. 1923, Staudacher leg.

Ljubljana, Dolsko, VM70, 12. 4. 1980, A. &amp; M. Gogala leg.

Vipavska dolina: Renče, UL98, 22. 7. 1980, A. &amp; M. Gogala leg.

Istra: Koštabona, Škrline, r. Dragonja, VL03, 25. 6. 1981, M. Gogala leg., 7. 6. 1987, A. &amp; M. Gogala leg.

Ljubljana, Sp. Gameljne, VM60, 11. 4. 1988, A. &amp; M. Gogala leg.

Istra: Osp, VL14, 18. 2. 1990, A. &amp; M. Gogala leg.

Prekmurje: Dolenja Bistrica, XM05, 23. 5. 1992, A. &amp; M. Gogala leg.

Braniška dolina: Sp. Branica, Čipnje, r. Branica, VL07, 23. 5. 1993, A. &amp; M. Gogala leg.

Braniška dolina: Kodreti, Dolanci, r. Branica, VL17, 25. 5. 1997, A. &amp; M. Gogala leg.

Istra: Dragonja, r. Dragonja, UL93, 10. 6. 1997, A. &amp; M. Gogala leg.

Kras: Škocjan, r. Reka, VL25, 25. 8. 2001, A. Gogala leg.  
Ilirska Bistrica, mrtvica pri Lesonitu, VL44, 4. 8. 2002, S. Polak leg.

Orešje na Bizeljskem, WM50, 25. 5. 1993, V. Furlan leg. et coll.

Muljava, VL88, 3. 3. 1992, V. Furlan leg. et coll.

Prekmurje: Dobrovnik, XM07, 26. 7. 1998, S. Gomboc &amp; D. Kofol leg. et coll.

Istra: Strunjan, Karbonar, UL94, 17. 5. 2003, A. &amp; M. Gogala leg.

Istra: Belvedur, r. Malinska, VL03, 4. 6. 2003, A. Gogala leg.

Veliidae

***Microvelia pygmaea*** (Dufour, 1833)

Horvath, 1887: Gorica

Gogala &amp; Gogala, 1986; Gogala &amp; Gogala, 1989

Unpublished records:

Kras: Petrinje, VL14, 28. 6. 1980, A. &amp; M. Gogala leg.

Vipavska dol.: Renče, UL98, 22. 7. 1980, A. &amp; M. Gogala leg.

Ljubljana, Sp. Gameljne, VM60, 11. 4. 1988, A. &amp; M. Gogala leg.

***Microvelia reticulata*** (Burmeister, 1835)*M. schneideri* (Scholtz, 1847)

Horvath, 1887: Gorica

Gogala &amp; Moder, 1960: Šmartno ob Savi, 2. 4. 1954, M. Gogala leg.

Gogala &amp; Gogala, 1986; Gogala &amp; Gogala, 1989

Unpublished records:

Laibach (= Ljubljana), 15. 10. 1944, Staudacher leg.

Ljubljansko barje: Ig, Matena, VL69, 24. 4. 1977, A. &amp; M. Gogala leg.

Prekmurje: Mursko Središče, slov. stran r. Mure, XM15, 6. 7. 1980, A. &amp; M. Gogala leg.

Prekmurje: Petišovci, XM15, 30. 4. 1983, A. &amp; M. Gogala leg.

Prekmurje: Bukovniško jezero, XM07, 30. 4. 1983, A. &amp; M. Gogala leg.

Prekmurje: Turnišče, XM06, 30. 4. 1983, A. &amp; M. Gogala leg.

Ljubljansko barje: Ig, Dobravica, Draga, VL68, 4. 5. 1985, A. &amp; M. Gogala leg.

Ljubljana, Sp. Gameljne, VM60, 11. 4. 1988, A. &amp; M. Gogala leg.

Prekmurje: Dolenja Bistrica, XM05, 23. 5. 1992, A. &amp; M. Gogala leg.

***Velia affinis filippii*** Tamanini, 1947

Tamanini, 1947: Isola d'Istria (= Izola)

Unpublished record:

Istra: Strunjan, Karbonar, UL94, 4. 6. 2003, A. Gogala leg.

***Velia caprai*** Tamanini, 1947

Tamanini, 1947: Beca (= Beka); Clanec (= Klanec pri Kozini); Corso Medio Risano (= Rižana r.)

Gogala &amp; Gogala, 1986; Gogala &amp; Gogala, 1989

Unpublished records:

Vipavska dol.: Ozeljan, VL08, 7. 4. 1979, A. &amp; M. Gogala leg.

Ljubljansko barje: Dragomer, VL59, 25. 4. 1983, A. &amp; M. Gogala leg.

Prekmurje: Goričko: Ocinje, WM78, 14. 6. 1987, A. &amp; M. Gogala leg.

Istra: Topolovec, r. Vruja, VL03, 16. 4. 1988, A. &amp; M. Gogala leg.

Šmarje pri Jelšah, WM42, 17. 8. 1988, A. &amp; M. Gogala leg.

Lužarji, izvir Iške, VL67, 12. 8. 1998, 1. 5. 1999, A. Gogala leg.

Istra: Ocizla, VL15, 3. 8. 2001, A. Gogala leg.

Slovenske gorice: Hlaponci, WM74, 23. 4. 1998, S. Brelih leg. et coll.

Braniška dolina: Kodreti, Dolanci, r. Branica, VL17, 7. 6. 2003, A. Gogala leg.

***Velia currens* (Fabricius, 1794)**

Tamanini, 1947: Plezzo (= Bovec)

? Gogala & Moder, 1960 (probably confused with other species)

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Bohinj: Bohinjska Bistrica, VM12, 20. 3. 1977, A. & M. Gogala leg.

Rakitna, VL58, 17. 2. 1980, A. & M. Gogala leg.

Ljubljansko barje: Ig, Matena, Iška Loka, VL69, 11. 4. 1982, A. & M. Gogala leg.

Ljubljansko barje: Podpeč, VL59, 6. 8. 1983, A. & M. Gogala leg.

Ljubljansko barje: Ig, Matena, VL69, 24. 4. 1977, 4. 5. 1985, A. & M. Gogala leg., 24. 4. 1999, S. Brelih leg. et coll.

Idrija, Krekovše, r. Belca, VL19, 28. 6. 1988, M. Gogala leg., 16. 8. 2003, A. Gogala leg.

Iški Vintgar, VL68, 14. 8. 1988, 25. 4. 1998, A. & M. Gogala leg.

Julijske Alpe: Bohinj, Voje, VM13, 25. 9. 1988, A. & M. Gogala leg.

Hotedršica, Žejna dolina, VL39, 29. 7. 1999, A. Gogala leg.

Lužarji, Iška pod izvirom, VL67, 12. 5. 2001, photo A. Gogala.

Borovnica, Pekel, r. Borovniščica, VL58, 6. 8. 2003, A. Gogala leg.

***Velia saulii* Tamanini, 1947 (Fig. 2)**

Tamanini, 1947: Istria, Val Recca (= Reka valley), 4. 1935: **holotype**; Corso Medio Risano, Villa Decani (= Rižana r., Dekani (Koper)), 4. 1936; Istria, Beca Ocisla (= Beka, Ocizla), 10. 1942

Unpublished record:

Braniška dol.: Kodreti, Dolanci, r. Branica, VL17, 7. 6. 2003, A. Gogala leg.

**Gerridae**

***Aquarius najas* (De Geer, 1773)**

Montandon, 1886: Gorica

Gräffe, 1911: Cerkniško jezero

Gogala & Moder, 1960: Iška, 25. 4. 1954, 28. 10. 1958, M. Gogala leg.; Domžale, 12. 4. 1954, M. Gogala leg.; Drava, 8. 10. 1955, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

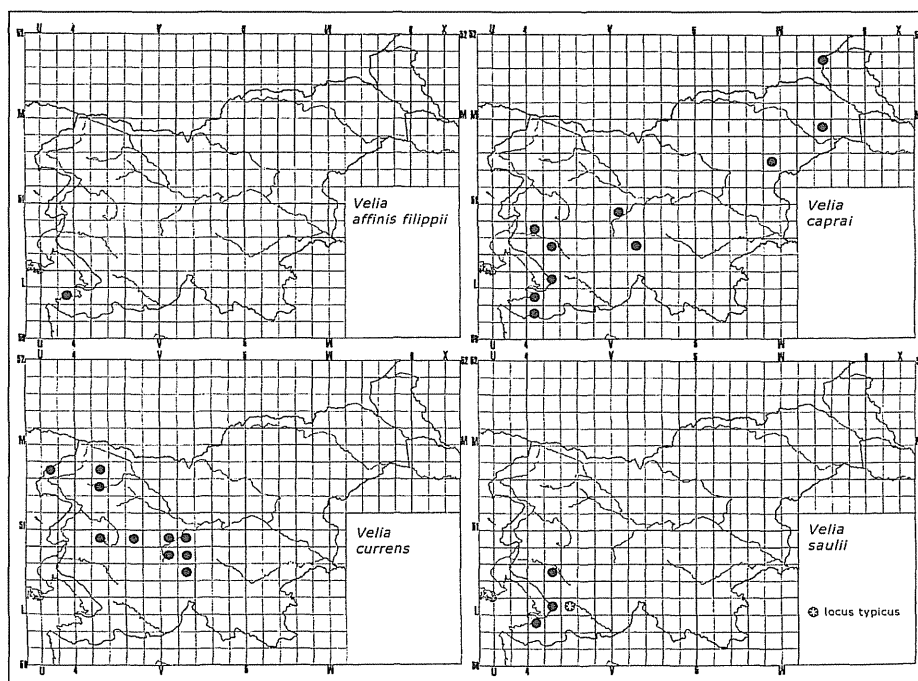
Laibach (= Ljubljana), 29. 8. 1939, Staudacher leg.

Ljubljana, Bokalce, VM50, 6. 1972, A. & M. Gogala leg.

Ljubljana: Trnovo, VL69, 12. 5. 1986, M. Gogala leg.

Istra: Topolovec, r. Vruja, VL03, 16. 4. 1988, A. & M. Gogala leg.

Iški Vintgar, VL68, 14. 8. 1988, A. & M. Gogala leg.



**Fig. 2: The distribution of all four *Velia* species living in Slovenia.**

**Sl. 2: Razširjenost vseh štirih vrst rodu *Velia*, ki živijo v Sloveniji.**

Istra: Koštabona, Supotski slap, VL03, 12. 10. 1988, A. & M. Gogala leg.

Istra: Osp, VL14, 18. 2. 1990, A. & M. Gogala leg.

Istra: izvir Rižane, VL14, 18. 3. 1990, A. & M. Gogala leg.

Istra: Sočerga, Mlini, VL13, 1. 8. 1990, A. & M. Gogala leg.

Braniška dolina: Sp. Branica, Čipnje, r. Branica, VL07, 18. 7. 1991, 23. 5. 1993, 25. 5. 1997, A. & M. Gogala leg.

Kras: Škocjan, r. Reka, VL25, 13. 3. 1999, A. Gogala leg.

#### ***Aquarius paludum*** (Fabricius, 1794)

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Laibach (= Ljubljana), 4. 6. 1938, Staudacher leg.

Kras: Petrinje, VL14, 1. 7. 1979, A. & M. Gogala leg.

Prekmurje: Mursko Središče, slov. stran r. Mure, XM15, 6. 7. 1980, A. & M. Gogala leg.

Prekmurje: Bukovniško jezero, XM07, 30. 4. 1983, A. & M. Gogala leg.

Prekmurje: Turnišče, XM06, 30. 4. 1983, A. & M. Gogala leg.

Planinsko polje: Planina, Laze, VL47, 11. 5. 1986, A. & M. Gogala leg.

Cerkniško jezero: Otok, VL56, 24. 5. 1987, A. & M. Gogala leg.

Kras: Brestovica pri Komnu, UL97, 2. 5. 1990, A. & M. Gogala leg.

Slovenske gorice: Hlaponci, WM74, 23. 4. 1998, S. Brelih leg. et coll.

Istra: Piran, Fjesa, Vel. jezerce, UL84, 17. 5. 2003, A. & M. Gogala leg.

#### ***Gerris argentatus*** Schummel, 1832

Gogala & Moder, 1960: Ljubljana, 14. 4. 1954, M. Gogala leg.; Črnuče, Brinje, 2. 4. 1954, M. Gogala leg.; Iška, 9. 10. 1954, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Ljubljansko barje: Ig, Dobravica, Draga, VL68, 29. 3. 1980, 4. 5. 1985, A. & M. Gogala leg.

Prekmurje: Mursko Središče, slov. stran r. Mure, XM15, 6. 7. 1980, A. & M. Gogala leg.

Prekmurje: Bukovniško jezero, XM07, 30. 4. 1983, A. & M. Gogala leg.

Prekmurje: Turnišče, XM06, 30. 4. 1983, A. & M. Gogala leg.

Prekmurje: Petišovci, XM15, 30. 4. 1983, A. & M. Gogala leg.

Bloke: Volčje, Bloško jezero, VL67, 23. 4. 1989, A. & M. Gogala leg.

Prekmurje: Mala Polana, Črni log, XM06, 23. 5. 1992, A. & M. Gogala leg.

Kranj, Bobovek, VM52, 26. 4. 1999, S. Brelih leg. et coll.

#### ***Gerris costae*** (Herrich-Schaeffer, 1850)

Gogala & Moder, 1960: Ljubljana, 23. 4. 1954, M. Gogala leg.; Sv. Katarina, 31. 8. 1953, M. Gogala leg.; Stol, 1600 m, 12. 6. 1954, M. Gogala leg.; Peričnik, F. J. Schmidt leg.; Sv. Lucija pri Portorožu, 20. 4. 1955, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Vipavska dolina: Ozeljan, VL08, 7. 4. 1979, A. & M. Gogala leg.

Bohinj: Bohinjska Bistrica, VM12, 5. 4. 1980, A. & M. Gogala leg.

Julijske Alpe: Nemški Rovt, VM22, 15. 8. 1981, A. & M. Gogala leg.

Pohorje: Sv. Areh, WM35, 24. 7. 1983, A. & M. Gogala leg.

Istra: Padna, UL93, 16. 6. 1984, A. & M. Gogala leg.

Rovte, Medvedje brdo, VL39, 19. 5. 1985, A. & M. Gogala leg.

Ljubljansko barje: Log, Lukovica, VL59, 26. 4. 1986, A. & M. Gogala leg.

Istra: Koštabona, VL03, 7. 8. 1986, 7. 6. 1987, A. & M. Gogala leg.

Karavanke: Solčava, Žibovt – Kislá voda, VM74, 26. 6. 1988, A. & M. Gogala leg.

Vipavska dolina: Ajdovščina, Planina, VL17, 25. 3. 1988, A. & M. Gogala leg.

Kras: Komen, Nadrožica, VL07, 5. 5. 1989, A. & M. Gogala leg.

Istra: Osp, VL14, 18. 3. 1990, A. & M. Gogala leg.

Lužarji, izvir Iške, VL67, 1. 5. 1999, A. Gogala leg.

Julijske Alpe: Vršič, Sleme, 1850 m, VM04, 1. 8. 2001, A. & M. Gogala leg.

Istra: Trebeše, r. Stranica, VL13, 14. 8. 2002, A. Gogala leg.

Hrastnik, WM01, 8. 4. 1996, A. Kapla leg. et coll.

Istra: Sirči, VL03, 21. 7. 1997, S. Brelih leg. et coll.

Istra: Strunjan, Karbonar, UL94, 17. 5. 2003, A. & M. Gogala leg.

Istra: Koper, Dekani, r. Rižana, VL04, 4. 6. 2003, A. Gogala leg.

#### ***Gerris gibbifer*** Schummel, 1832

Horvath, 1887: Gorica

#### ***Gerris lacustris*** (Linnaeus, 1758)

Montandon, 1886: Gorica

Gogala & Moder, 1960: Ljubljana, 4., M. Gogala leg.; Dravljje, 12. 7. 1851, F. J. Schmidt leg.; Črnuče, Brinje, 2. 4. 1954, M. Gogala leg.; Brežice, 7. 8. 1958, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Ljubljansko barje: Studenec – Ig, VL69, 4. 8. 1928, Staudacher leg.

Ljubljansko barje: Ig, Matena, VL69, 24. 4. 1977, A. & M. Gogala leg.  
 Ljubljansko barje: Bevke, VL59, 20. 2. 1977, A. & M. Gogala leg.  
 Vipavska dolina: Ozeljan, VL08, 7. 4. 1979, A. & M. Gogala leg.  
 Kras: Petrinje, VL14, 15. 4. 1979, A. & M. Gogala leg.  
 Bohinj: Bohinjska Bistrica, VM12, 5. 4. 1980, A. & M. Gogala leg.  
 Istra: Koštabona, VL03, 25. 6. 1981, M. Gogala leg.  
 Ljubljansko barje: Log, Lukovica, VL59, 10. 7. 1981, A. & M. Gogala leg.  
 Vipavska dolina: Renče, UL98, 22. 7. 1980, A. & M. Gogala leg.  
 Planinsko polje: Planina, Laze, VL47, 11. 6. 1982, 11. 5. 1986, A. & M. Gogala leg.  
 Prekmurje: Bukovniško jezero, XM07, 30. 4. 1983, A. & M. Gogala leg.  
 Prekmurje: Turnišče, XM06, 30. 4. 1983, A. & M. Gogala leg.  
 Pokljuka: barje Šijec, VM23, 26. 6. 1985, A. & M. Gogala leg.  
 Istra: Boršt, VL03, 3. 5. 1986, A. & M. Gogala leg.  
 Planinsko polje: Planina, VL47, 11. 5. 1986, 11. 5. 2001, A. & M. Gogala leg.  
 Bloke: Volčje, Bloško jezero, VL67, 19. 4. 1987, A. & M. Gogala leg.  
 Cerknško jezero: Otok, VL56, 24. 5. 1987, A. & M. Gogala leg.  
 Pomurje: Veržej, WM96, 13. 6. 1987, A. & M. Gogala leg.  
 Vipavska dolina: Ajdovščina, Planina, VL17, 25. 3. 1988, A. & M. Gogala leg.  
 Borovnica, Pekel, VL58, 27. 4. 1988, A. & M. Gogala leg.  
 Rakov Škocjan, VL47, 7. 5. 1988, A. & M. Gogala leg.  
 Istra: Črnotiče, VL14, 18. 3. 1990, A. & M. Gogala leg.  
 Kras: Brestovica pri Komnu, UL97, 2. 5. 1990, A. & M. Gogala leg.  
 Istra: Gradin, Koromači, VL03, 5. 8. 1999, A. Gogala leg.  
 Istra: Trebeše, r. Stranica, VL13, 14. 8. 2002, A. Gogala leg.  
 Cerknško jezero: Gorica, VL56, 29. 8. 2000, S. Brelih leg. et coll.  
 Slovenske gorice: Hlaponci, WM74, 23. 4. 1998, S. Brelih leg. et coll.  
 Kranj, Bobovek, VM52, 26. 4. 1999, S. Brelih leg. et coll.  
 Ilirska Bistrica, mrtvica pri Lesonitu, VL44, 4. 8. 2002, S. Polak leg.  
 Istra: Strunjan, Karbonar, UL94, 17. 5. 2003, A. & M. Gogala leg.  
 Istra: Koper, Dekani, ob Rižani, VL04, 4. 6. 2003, A. Gogala leg.

***Gerris odontogaster*** (Zetterstedt, 1828)

? Andersen, 1995: Slovenia

***Gerris thoracicus*** Schummel, 1832

Gogala & Moder, 1960: Ljubljana, 23. 4. 1954, M. Gogala leg.; Črnuče, Brinje, 2. 4. 1954, M. Gogala leg.  
 Gogala & Gogala, 1986; Gogala & Gogala, 1989  
 Unpublished records:  
 Ljubljansko barje: Log, Lukovica, VL59, 2. 4. 1977, A. & M. Gogala leg.  
 Kras: Petrinje, VL14, 15. 4. 1979, A. & M. Gogala leg.  
 Ljubljansko barje: Ig, Matena, Iška Loka, VL69, 11. 4. 1982, A. & M. Gogala leg.  
 Planinsko polje: Planina, VL47, 11. 5. 1986, A. & M. Gogala leg.  
 Cerknško jezero: Otok, VL56, 27. 4. 1990, A. & M. Gogala leg.

***Gerris asper*** (Fieber, 1860)

? Andersen, 1995: Slovenia

***Limnopus rufoscutellatus*** (Latreille, 1807)

? Andersen, 1995: Slovenia

LEPTOPODOMORPHA

Saldidae

***Chartoscirta cincta*** (Herrich-Schaeffer, 1841)

Montandon, 1886: Gorica  
 Protić, 1998: Podčetrtek, 30. 6. 1930, E. Jaeger leg.  
 Unpublished records:  
 Gradišče pri Lukovici, VM71, 31. 7. 1996, A. & M. Gogala leg.  
 Cerknško jezero: Gorenje Jezero, r. Obrh, VL56, 21. 7. 2002, A. Gogala leg.

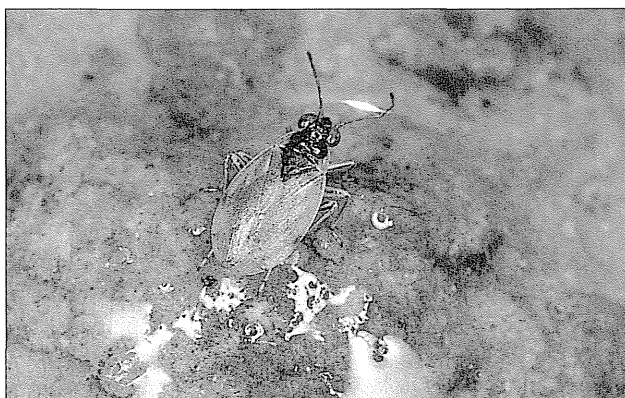
***Chartoscirta cocksii*** (Curtis, 1835)

Montandon, 1886: Gorica  
 Gogala & Moder, 1960: Sečovelje, 21. 4. 1955, M. Gogala leg.  
 Gogala & Gogala, 1986; Gogala & Gogala, 1989  
 Protić, 1998: Podčetrtek, 12. 11. 1934, E. Jaeger leg.  
 Unpublished records:  
 Laibach (= Ljubljana), 3. 11. 1935, Staudacher leg.  
 Ljubljansko barje: Log, Lukovica, VL59, 19. 3. 1983, 12. 4. 1983, A. & M. Gogala leg.  
 Istra: Sočerga, Mlini, VL13, 1. 8. 1990, A. & M. Gogala leg.  
 Ilirska Bistrica, Zarečje, VL34, 31. 5. 1999, S. Brelih leg. et coll.

***Halosalda lateralis*** (Fallén, 1807)

Gogala & Gogala, 1989; Gogala, 1992  
 Unpublished records:  
 Istra: Sečovelje, Fontanigge, UL93, 2. 10. 1986, M. Gogala leg., 6. 5. 2000, A. & M. Gogala leg., 18. 9. 2003 (Fig. 3)





**Fig. 3: *Halosalda lateralis* is known to live in Slovenia only at the Sečovlje salt-pans. (Photo: A. Gogala)**  
**Sl. 3: *Halosalda lateralis* živi v Sloveniji samo v Sečoveljskih solinah. (Foto: A. Gogala)**

***Macrosaldula scotica* (Curtis, 1835)**

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Ljubljana, Črnuče, r. Sava, VM60, 3. 6. 1979, A. & M. Gogala leg.

Medvode, Goričane, r. Sora, VM51, 15. 7. 1980, A. & M. Gogala leg.

Medvode, Sora, Draga, r. Sora, VM51, 22. 7. 1982, A. & M. Gogala leg.

Brod na Kupi, Petrina, r. Kolpa, VL83, 27. 7. 1985, A. & M. Gogala leg.

Julijske Alpe: Krnska jezera, UM92, 31. 7. 1988, A. & M. Gogala leg.

Kras: Škocjan, Naklo, r. Reka, VL25, 29. 8. 1998, A. Gogala leg.

***Macrosaldula variabilis* (Herrich-Schaeffer, 1835)**

Montandon, 1886: Gorica

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Istra: Koštabona, r. Dragonja, VL03, 25. 6. 1981, M. Gogala leg., 7. 8. 1986, A. & M. Gogala leg.

Ljubljana, Tomačevo, r. Sava, VM60, 14. 6. 1983, A. & M. Gogala leg.

***Saldula c-album* (Fieber, 1859)**

Gogala & Moder, 1960: Bohinj, 2. 5. 1955, 20. 8. 1956, M. Gogala leg.; ob Korošici, 29. 5. 1950, M. Gogala leg.

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Bohinj: Ukanc, r. Savica, VM02, 30. 4. 1978, A. & M. Gogala leg.

Idrija, Divje jezero, VL29, 13. 4. 1980, A. & M. Gogala leg.

Julijske Alpe: Nemški Rovt, VM22, 15. 8. 1981, A. & M. Gogala leg.

Kamniško-Savinjske Alpe: Jezersko, VM63, 14. 8. 1983, A. & M. Gogala leg.

Idrija, Krekovše, r. Belca, VL19, 28. 6. 1988, M. Gogala leg.

Hrastnik, WM01, 6. 4. 2000, A. Kapla leg.

Hrastnik, r. Sava, 210 m, WM00, 12. 7. 2002, A. Kapla leg.

Ljutomer, Podgradje, ribnik, 180 m, WM95, 27. 5. 1997, S. Brelih leg. et coll.

***Saldula melanoscela* (Fieber, 1859)**

Horvath, 1887: Gorica

Gogala & Gogala, 1986

Protić, 1998: Podčetrtek, 12. 11. 1934, E. Jaeger leg.

Unpublished records:

Ljubljansko barje: Log, Lukovica, VL59, 10. 7. 1981, A. Gogala leg.

Prekmurje: Petišovci, XM15, 30. 4. 1983, A. & M. Gogala leg.

Istra: Sočerga, Mlini, VL13, 1. 8. 1990, A. & M. Gogala leg.

***Saldula opacula* (Zetterstedt, 1838)**

? Lindskog, 1995: Slovenia

***Saldula orthochila* (Fieber, 1859)**

Gogala & Gogala, 1986; Gogala & Gogala, 1989

Unpublished records:

Julijske Alpe: Ratitovec, VM22, 18. 8. 1946, Pretner leg.

Kamniško-Savinjske Alpe: Velika planina, VM72, 15. 10. 1978, A. & M. Gogala leg.

Julijske Alpe: Pl. Lipanca, VM13, 2. 9. 1979, A. & M. Gogala leg.

Julijske Alpe: Zg. Radovna, VM14, 28. 8. 1988, A. & M. Gogala leg.

Snežnik, VL54, 22. 7. 1992, A. & M. Gogala leg.

***Saldula pallipes* (Fabricius, 1794)**

Gogala & Moder, 1960: Ljubljana, M. Gogala leg.; Ig, 9. 10. 1954, M. Gogala leg.; Bohinj, Vogel, 8. 1958, M. Gogala leg.

Gogala & Gogala, 1986 (partly confused with *S. palustris*!); Gogala & Gogala, 1989 (confused with *S. palustris*!)

Unpublished records:

Bohinj: Ukanc, Bohinjsko jezero, VM02, 24. 8. 1980, A. & M. Gogala leg.

Planinsko polje: Laze, VL47, 21. 6. 2000, A. Gogala leg.

Bloke: Volčje, Bloško jezero, VL67, 2. 7. 2000, A. Gogala leg.

Planinsko polje: Planina, r. Unica, VL47, 14. 8. 2001, A. Gogala leg.

Ormož, Frankovci, gram. Jurkovec, WM94, 24. 7. 2002, A. Kapla leg.

Cerkniško jezero: Gorica, VL56, 29. 8. 2000, S. Brelih leg. et coll.

***Saldula palustris*** (Douglas, 1874)

Unpublished records:

Istra: Koper, Bertoki, Škocjanski zatok, VL04, 1. 7. 1979, 18. 5. 1980, A. &amp; M. Gogala leg., 10. 6. 2000, 8. 8. 2000, 11. 8. 2000, A. Gogala leg.

Istra: Sočerga, Mlini, VL13, 1. 8. 1990, A. &amp; M. Gogala leg.

Istra: Koštabona, r. Dragonja, VL03, 7. 8. 1986, A. &amp; M. Gogala leg.

Istra: Sečovelje, Fontanigge, UL93, 2. 3. 1996, 8. 4. 2000, A. Gogala leg.

Istra: Ankaran, VL04, 28. 10. 2000, A. &amp; M. Gogala leg.

Istra: Koper, Škocjanski zatok, VL04, 23. 5. 2000, S. Brelih leg. et coll.

***Saldula pilosella hirsuta*** (Reuter, 1888)

Gogala &amp; Gogala, 1986; Gogala, 1992

Unpublished records:

Istra: Koper, Bertoki, Škocjanski zatok, VL04, 1. 7. 1979, A. &amp; M. Gogala leg., 10. 6. 2000, 11. 8. 2000, A. Gogala leg.

Istra: Sečovelje, Fontanigge, UL93, 2. 3. 1996, A. Gogala leg.

***Saldula saltatoria*** (Linnaeus, 1758)

Gogala &amp; Moder, 1960: Ljubljana, 25. 5. 1954, M. Gogala leg.; Črnuče, Brinje, 5. 7. 1954, M. Gogala leg.

Gogala &amp; Gogala, 1986; Gogala &amp; Gogala, 1989.

Unpublished records:

Kamniško-Savinjske Alpe: Velika planina, VM72, 15. 10. 1978, A. &amp; M. Gogala leg.

Ljubljana, Dobrova, VM50, 27. 5. 1979, A. &amp; M. Gogala leg.

Ljubljana, Dolsko, VM70, 12. 4. 1980, A. &amp; M. Gogala leg.

Bohinj: Ukanc, Bohinjsko jezero, VM02, 24. 8. 1980, A. &amp; M. Gogala leg.

Prekmurje: Petišovci, XM15, 30. 4. 1983, A. &amp; M. Gogala leg.

Planinsko polje: Laze, VL47, 21. 5. 1983, 21. 6. 2000, A. &amp; M. Gogala leg.

Kamniško-Savinjske Alpe: Jezersko, VM63, 14. 8. 1983, A. &amp; M. Gogala leg.

Ljubljansko barje: Podpeč, VL59, 6. 8. 1983, A. &amp; M. Gogala leg.

Ljubljansko barje: Ig, Dobravica, Draga, VL68, 4. 5. 1985, A. &amp; M. Gogala leg.

Cerkniško jezero: Dolenje Jezero, VL56, 28. 6. 1985, A. &amp; M. Gogala leg.

Prekmurje: Goričko: Ocinje, WM78, 14. 6. 1987, A. &amp; M. Gogala leg.

Bloke: Volčje, Bloško jezero, VL67, 11. 7. 1987, 2. 7. 2000, A. &amp; M. Gogala leg.

Rakov Škocjan, VL47, 7. 5. 1988, A. &amp; M. Gogala leg.

Julijske Alpe: Krnska jezera, UM92, 31. 7. 1988, A. &amp; M. Gogala leg.

Vipavska dolina: M. Žablje, VL18, 23. 5. 1993, A. &amp; M. Gogala leg.

Iški Vintgar: Vrbica, VL68, 9. 8. 1998, 20. 4. 2000, 20. 6. 2000, A. Gogala leg.

Planinsko polje: Planina, VL47, 22. 4. 2000, A. Gogala leg.

Planinsko polje: Planina, r. Unica, VL47, 14. 8. 2001, A. Gogala leg.

Cerkniško jezero: Gorica, VL56, 29. 8. 2000, S. Brelih leg. et coll.

Ljutomer, Podgradje, ribnik, 180 m, WM95, 27. 5. 1997, S. Brelih leg. et coll.

Prekmurje: Vučja Gomila, WM97, 2. 6. 1999, S. Brelih leg. et coll.

***Salda adriatica*** Horváth, 1887

Unpublished record:

Istra: Sečovelje, Fontanigge, UL93, 20. 6. 2001, A. Gogala leg.

## Leptopodidae

***Leptopus marmoratus*** (Goeze, 1778)

Montandon, 1886: Gorica

Gogala &amp; Gogala, 1986:

Isonzo (= Soča r.), coll. F. J. Schmidt

***Patapius spinosus*** (Rossi, 1790)

Unpublished record:

Kras: Brje pri Komnu, VL07, 19. 9. 1999, J. Šporar, A. &amp; M. Gogala leg.

## Species omitted from the list

***Micronecta minutissima*** (Linnaeus, 1758)

Gogala &amp; Moder, 1960: probably a misidentification.

Gogala & Gogala, 1986: confused with *M. scholtzi*.Gogala & Gogala, 1989: confused with *M. griseola*.***Notonecta obliqua*** Thunberg, 1787Gogala & Moder, 1960; Gogala & Gogala, 1986: probably dark specimens of *N. meridionalis* and *N. glauca*.***Saldula pilosella pilosella*** (Thomson, 1871)Gogala & Gogala, 1986: only a single aberrant specimen of *S. p. hirsuta*.

## DISCUSSION

Water bugs have been poorly studied in Slovenia. Several additional species could possibly be found in the north-eastern (sub-Pannonian) part of the country, where water habitats are numerous.

*Hebrus ruficeps* was trapped on the bank of an oxbow pond near the Mura river. It is probably not present near Ljubljana any more. Mura's oxbows are also a

habitat to *Mesovelia furcata*, which was found on Ljubljana Moors only about 50 years ago.

Salt marshes on the coast, especially the Sečovlje salt-pans, are home to several species of shore bugs, which live only there. *Salda adriatica* and the subspecies *Saldula pilosella hirsuta* were described from the Italian coast not far from here. The latter is endemic to the Adriatic basin.

The only so far known habitat of *Velia affinis filippii* is the Roja stream and its tributaries in Strunjan. The species had not been found in Izola anymore, although reported from there by Tamanini (1947). The probable

cause is a water accumulation on the stream there and its pollution. I was also unsuccessful when trying to find *Velia saulii* on its type locality. The river Reka has been badly polluted in the past.

*Patapius spinosus* was found in the Kras (Karst) region as a single specimen, coming to a table. *Notonecta meridionalis* and *Saldula palustris* were recognized among the previously collected material.

Although some species are still very numerous, water and shore bugs are among the most vulnerable Heteroptera species. Their habitats have shrunk much in the past and it is hoped that this trend will be stopped in the future.

## HETEROPTERA SLOVENIJE, I.: DIPSOCOROMORPHA, NEPOMORPHA, GERROMORPHA IN LEPTOPODOMORPHA

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### POVZETEK

Objavljen je seznam stenic infraredov Dipsocoromorpha, Nepomorpha, Gerromorpha in Leptopodomorpha, ki živijo v Sloveniji. Povzeti so podatki iz literature. Material iz zbirke Prirodoslovnega muzeja Slovenije je bil ponovno pregledan, navedeni so vsi znani podatki o najdiščih in datumih najdb. Vrste *Notonecta meridionalis*, *Saldula palustris*, *Salda adriatica* in *Patapius spinosus* so prvič zabeležene v Sloveniji. Pojasnjeno je tipsko najdišče vrste *Velia saulii*.

**Ključne besede:** Heteroptera, Dipsocoromorpha, Nepomorpha, Gerromorpha, Leptopodomorpha, Slovenija, favna

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## NAJDBA ETRUŠČANSKE ROVKE *SUNCUS ETRUSCUS* (SAVI, 1822) NA OTOKU LOŠINJU (HRVAŠKA)

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### IZVLEČEK

Čeprav je etruščanska rovka *Suncus etruscus* v evropskem Sredozemlju splošno razširjena, so najdbe z otokov razmeroma maloštevilne. Od jadranskih otokov je znana samo s Cresa in Krka. Dne 15. maja 2001 smo pri Nerezinah na otoku Lošinju našli kadaver etruščanske rovke z dobro ohranjenim rostrumom in obema mandibulama. Žival je bila najdena v evmediteranski vegetaciji tipa Orno – Quercetum ilicis 150 m od morja na nadmorski višini 15 m.

**Ključne besede:** *Suncus etruscus*, razširjenost, otoška diverziteta, Hrvaška

## RITROVAMENTO DEL MUSTIOLO *SUNCUS ETRUSCUS* (SAVI, 1822) SULL'ISOLA DI LUSSINO (CROAZIA)

### SINTESI

Sebbene il mustiolo *Suncus etruscus* sia una specie a diffusione europeo-mediterranea, le segnalazioni insulari di tale specie sono poco frequenti. Per l'Adriatico sono noti gli avvistamenti inerenti le isole di Cherso e Veglia. Il 15 maggio 2001 gli autori hanno trovato il cadavere di un mustiolo con il rostro e le mandibole ben conservati, nei pressi della località di Nerezine sull'isola di Lussino. L'esemplare è stato ritrovato nella vegetazione sempreverde Orno-Quercetum ilicis, a 150 metri dal mare, ad un'altitudine di 15 metri.

**Parole chiave:** mustiolo, *Suncus etruscus*, diffusione, diversità insulare, Croazia

## UVOD

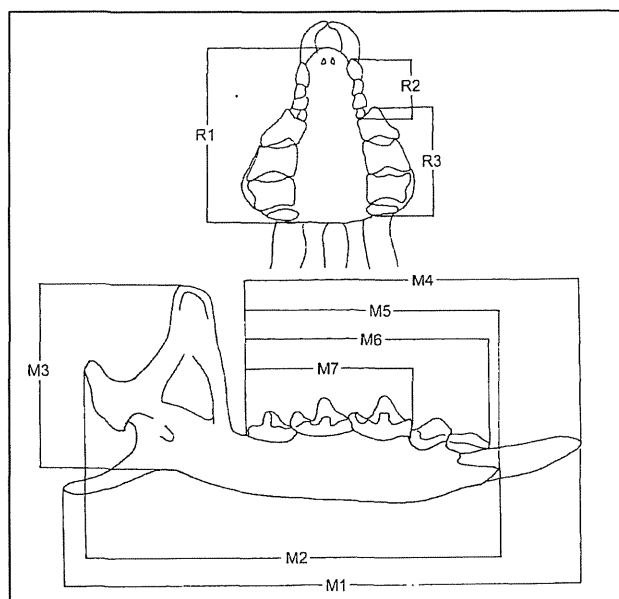
Etruščanska rovka *Suncus etruscus* (Savi, 1822) nase-ljuje južni palearktis, orientalis in zahodno ter vzhodno Afriko. Ker je taksonomski status orientalskih oblik dvomljiv (nekateri so morda samostojne vrste) so posledično tudi arealne meje slabo znane (Hutterer, 1993). V evropskem Sredozemlju je široko razširjena od Pirenejskega polotoka do evropske Turčije in zahodnih obal Anatolije (Spitzenberger, 1990; Mitchell-Jones *et al.*, 1999; Vohralík & Sofianidou, 2000). Njeno razširjenost dobro napovedo preprosti klimatski dejavniki: povprečna letna izoterma 12°C (Kahmann & Altner, 1956; Popov & Nijagolov, 1991), povprečna julijska temperatura 20°C (Fayard, 1984) in izoterma 0°C najhladnejšega meseca (Lipej & Kryštufek, 1991; Stojanovski, 1998). Videti je, da ima največjo napovedovalno moč izoterma 0°C najhladnejšega meseca, čeprav obstajajo v zahodni Aziji v tem pogledu tudi izjeme (Spitzenberger, 1990; Kryštufek *et al.*, 2001).

Od otokov je bila vrsta najdena na Mallorci, Korziki, Sardiniji, Siciliji, Malti, Pantelleriji, Krku, Cresu, Kreti, Khiosu, Samosu, Kosu, Rodosu in Cipru (Spitzenberger, 1990; Petrov, 1992; Mitchell-Jones *et al.*, 1999; Kryštufek *et al.*, 2001), živi pa tudi na Kanarskih otokih (Mitchell-Jones *et al.*, 2001). Kljub temu da je gostota najdišč na nekaterih otokih velika (npr. Korzika in Sardinija; Sans-Coma *et al.*, 1981), pa je otoška razširjenost slabo znana. V tem prispevku poroča o najdbi etruščanske rovke na Lošinju, kar je tretji podatek za jadranske otoke.

## MATERIAL IN METODE

Primerki, na katerem temelji prispevek, smo našli po naključju 15. junija 2001. Gre za kadaver, ki je ležal povožen na cesti. Čeprav je bil močno poškodovan, so bili rostrum in obe mandibuli dobro ohranjeni. Preparirani lobanjski ostanki so shranjeni v zbirki Oddelka za biologijo Pedagoške fakultete Univerze v Mariboru. Material smo determinirali in fotografirali pod stereo mikroskopom. Z digitaliziranih posnetkov smo s pomočjo računalniškega programa tps Dig (Rohlf, 2001) izmerili sledeče dimenzije (Sl. 1):

M1 – dolžina spodnje čeljustnice od 1. spodnjega sekalca do konca kotnega podaljška; M2 – dolžina spodnje čeljustnice od spodnječeljustnične glave do sprednječeljustnične simfize; M3 – koronoidna višina; M4 – največja dolžina spodnjega zobnega niza; M5 – razdalja med 3. spodnjim meljakom in spodnječeljustnično simfizo; M6 – razdalja od spodnjega podočnika do 3. spodnjega meljaka; M7 – dolžina spodnjih meljakov; R1 – dolžina rostruma; R2 – dolžina zgornjih enogričastih zob; R3 – dolžina zgornjih kočnikov.



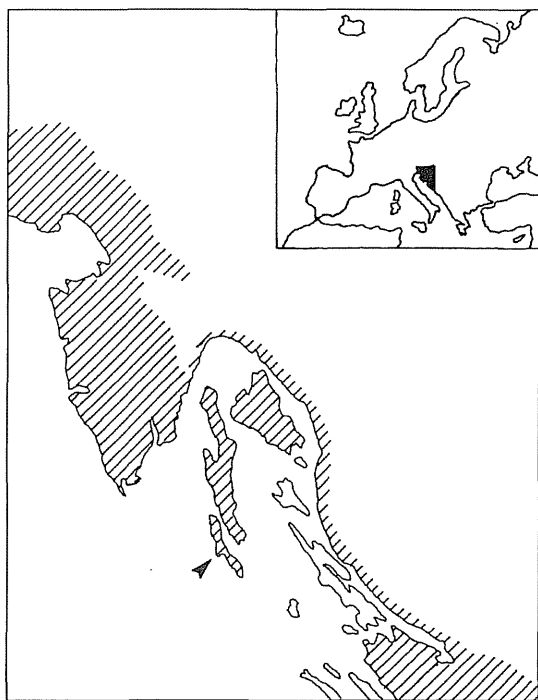
Sl. 1: Dimenzije spodnje čeljustnice in rostruma, ki smo jih uporabljali v tem delu (glej tudi besedilo).

Fig. 1: Rostral and mandibular measurements of the pygmy white-toothed shrew used in this study (see also text).

## REZULTATI IN DISKUSIJA

Primerki smo našli v turističnem naselju Bučanje pri kraju Nerezine na otoku Lošinju (Hrvaška; Sl. 2). Lošinj je srednje velik jadranski otok (površina 74,68 km<sup>2</sup>) z značilno sredozemsko klimo. Povprečna letna temperatura na bližnjem Malem Lošinju znaša 15,1°C, julijsko povprečje je 23,8°C, januarsko pa 7,3°C (Stražičić, 1981). Primerki je bil najden kakih 150 m od morja na nadmorski višini cca. 15 m. Vegetacija tega območja pripada evmediteranski združbi *Orno – Quercetum ilicis* (Jovanović *et al.*, 1986). Kot je to v Sredozemlju pogosto, je primarna vegetacija degradirana. Na SV otoka Lošinja (območje občin Nerezine, Sv. Jakov in Osor) prevladuje gozd, ki skupaj z različnimi sukcesivnimi stadiji makije in garige obsega 45% površine, pašnikov in kamnitih travšč je 43%, 4% je vinogradov, 4% oljčnih nasadov, 3% njiv in vrtov in 1% neplodnih površin. Pečat današnjemu stanju gozdov na Lošinju sta dali sečnja dreves in paša ovac.

Razpoložljivi primerki kljub poškodovanosti kaže niz diagnostičnih značilnosti, tako da determinacija ni vprašljiva. V zgornji čeljustnici so jasno vidni štirje enogričasti zobje, medtem ko so pri sorodnem rodu *Crocidura* takšni zobje le trije (Kryštufek & Janžeković, 1999). Koronoidna višina spodnje čeljustnice (M3 = 2,8 mm; Sl. 3) je v okviru variacijske širine za etruščansko rovko (Tab. 1) in je občutno manjša kot pri vrtni rovki *Crocidura suaveolens* (Pallas, 1811). Tudi natančnejša primerjava z lobanjskimi dimenzijami velike serije etru-



Sl. 2: Razširjenost etruščanske rovke v severnem Jadranu. Najdišče na Lošinju je označeno s puščico. V desnem zgornjem vogalu je prikazan položaj preučevanega območja.

Fig. 2: Distributional range of the pygmy white-toothed shrew in the northern Adriatic. Insert shows the position of the study area.

Tab. 1: Lobanjske dimenzije (v mm) etruščanske rovke z Lošinja in variacijska širina vzorca iz južne Francije (po Sans-Coma et al. 1981). Za oznake parametrov glej besedilo in sliko 1.

Tab. 1: Cranial measurements (mm) of *Suncus etruscus* from the island of Lošinj and the variation range for a sample from southern France (from Sans-Coma et al. 1981). For abbreviations see figure 1.

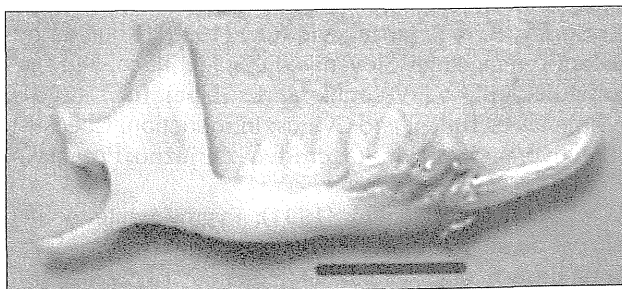
Znak / Character	otok Lošinj / Lošinj Island	južna Francija / Southern France
M1	7,9	7,64 – 8,50
M2	5,9	5,93 – 6,59
M3	2,8	2,68 – 2,97
M4	5,0	4,74 – 5,40
M5	3,6	3,56 – 3,95
M6	3,5	3,43 – 3,82
M7	2,6	2,42 – 2,75
R1	4,8	4,48 – 5,01
R2	1,6	1,36 – 1,65
R3	3,1	2,87 – 3,16

ščanskih rovke iz južne Francije (Sans-Coma et al., 1981) kaže, da se primerki z Lošinja v ničemer ne razlikujejo od etruščanskih rovke iz zahodnega Sredozemlja (Tab. 1).

To je v skladu z mnenjem, da v Evropi vrsta ni izpostavljena geografski variabilnosti v morfometričnih znakih (Spitzenberger, 1991).

Zanimivo je, da etruščanska rovka na jadranskih otokih doslej ni bila najdena na izrazito majhnih otokih. Vsa nahajališča so tudi s severnojadranskih otokov, ki so manj degradirani kot otoki v srednjem in južnem Jadranu. Najpogostejša rovka na jadranskih otokih je namreč vrtna rovka *C. suaveolens*, ki je doslej znana z enajstih otokov (Petrov, 1992). Vrtna rovka živi tudi na vseh treh otokih, za katere je bila ugotovljena etruščanska rovka. Znano je, da na otokih živi manjše število vrst kot na enako veliki kopni površini (Rosenzweig, 1996) in da imajo ozko sorodne ter morfološko in ekološko podobne vrste težave z razslojevanjem ekološke niše, posledica česar je kompetitivno izključevanje. Zadnje trditve podpira biogeografski vzorec dveh na jadranskih otokih splošno razširjenih vrst skalnih kuščaric (*Podarcis melisellensis* in *P. sicula*), ki se na večini otokov pojavljata alopatrično (Radovanović, 1951). Možno je torej, da je simpatija etruščanske in vrtna rovka na treh največjih otokih del vzorca, po katerem široko razširjena vrtna rovka z manjših in/ali degradiranih otokov izrine etruščansko rovko oziroma prepreči njeno doselitev. Če velja ta razlaga, potem je redkost najdb etruščanske rovke na jadranskih otokih resnična. Možna pa je seveda tudi razlaga, po kateri je sedanja redkost etruščanske rovke navidezna in je vrsta v Jadranu (in Sredozemlju) širše razprostranjena. Obstoj etruščanske rovke je namreč težko registrirati s standardno metodologijo vzorčenja malih sesalcev (Lipej & Kryštufek, 1991; Kryštufek et al., 2001).

Ker je otoška favna sesalcev zelo siromašna s številom vrst (za jadranske otoke glej npr. Tvrković et al., 1986; Petrov, 1992), lahko nepotrjeno pojavljanje vsakega terestričnega sesalca bistveno vpliva na oceno odnosa med površino in številom vrst (Rosenzweig, 1996). Posledica takšne anomalije je napačna percepcija dejanskega vzorca otoške biodiverzitete.



Sl. 3: Desna spodnja čeljustnica etruščanske rovke *Suncus etruscus*, najdena v Nerezinah na Lošinju, Hrvaška (merilo = 2 mm).

Fig. 3: Right mandible of the pygmy white-toothed shrew *Suncus etruscus* from Nerezine on the Island of Lošinj, Croatia (scale bar = 2 mm).



RECORD OF THE PIGMY WHITE-TOOTHED SHREW *SUNCUS ETRUSCUS* (SAVI, 1822)  
ON THE ISLAND OF LOŠINJ (CROATIA)

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## SUMMARY

Although the pigmy white-toothed shrew *Suncus etruscus* is widespread in the European Mediterranean, records from its islands are fairly uncommon. As far as the Adriatic islands are concerned, it has been reported only from Cres and Krk. On May 15, 2001, we found a carcass of the pigmy white-toothed shrew with well-preserved rostrum and both mandibles at Nerezine on the island of Lošinj. The specimen comes from the evergreen vegetation of the Orno – Quercetum ilicis type at an altitude of 15 m above sea level and some 150 m away from the seashore.

**Key words:** *Suncus etruscus*, distribution, island diversity, Croatia

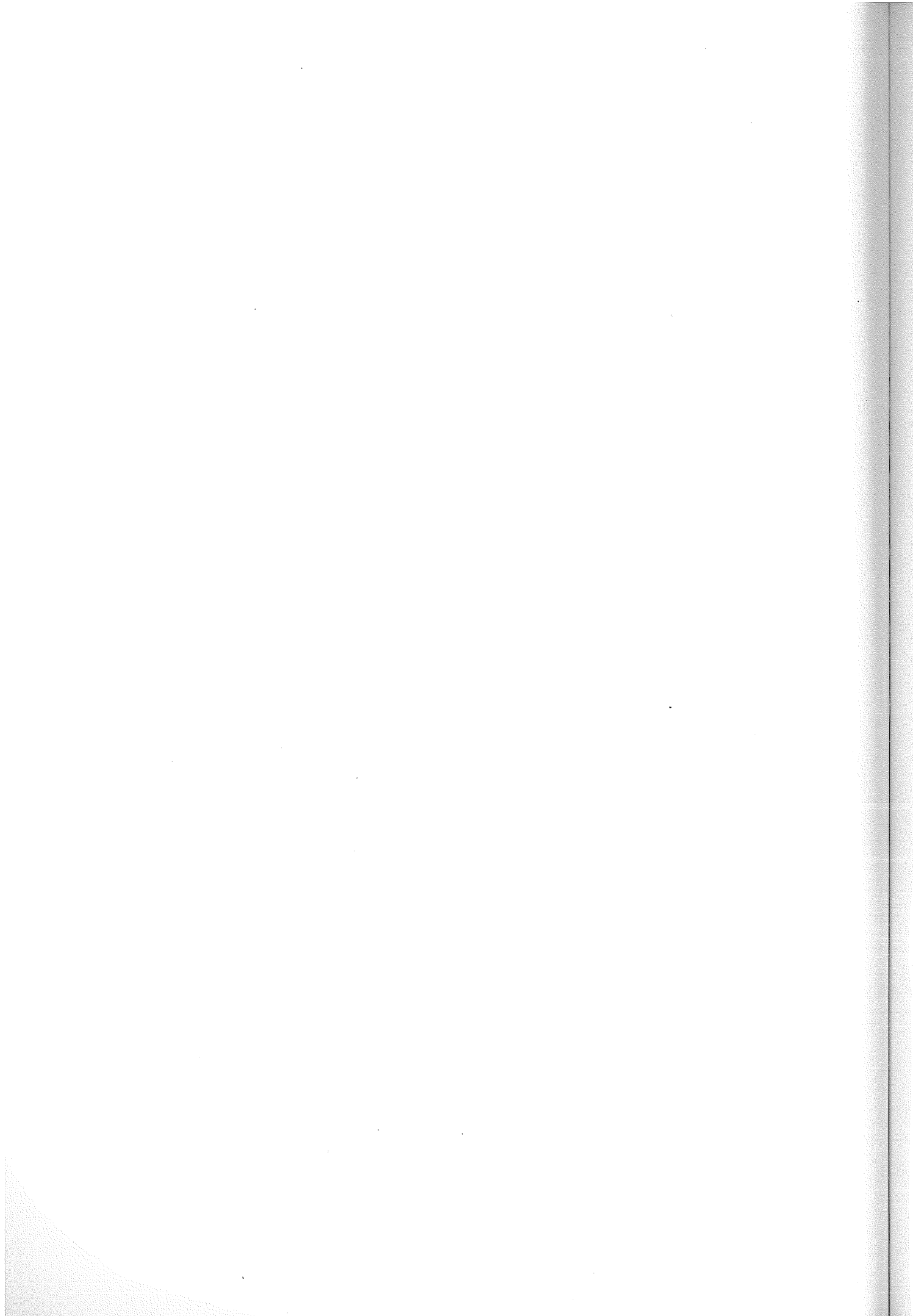
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## SHORE PLATFORMS ALONG THE NORTH-WESTERN ISTRIAN COAST: AN OVERVIEW

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### ABSTRACT

*This paper examines, by means of a survey of the platform width and repeated morphological observations compared to anemographic features, the morphology and processes concerning the development of shore platforms along the north-western Istrian coast, between Muggia and Piran. Platform width mainly controlled by fetch and wind exposure, ranged from 20 m, in the embayments, to 80 m, next to the headlands. This study, far from being exhaustive, aims at being a starting point in the understanding of local shore platforms. Platform erosion seems to be the result of subaerial weathering on the higher platform, of biological weathering that alternatively protects and attacks intertidal flysch, and of waves, which, by removing sediments, exert abrasive action on the bedrock.*

**Key words:** Shore platforms, Istrian coasts, Adriatic Sea, cliffs

## PIATTAFORME COSTIERE LUNGO LA COSTA NORD-OCCIDENTALE DELL'ISTRIA: UNA PANORAMICA

### SINTESI

*Si esaminano, mediante il rilievo dell'ampiezza della piattaforma e con osservazioni morfologiche ripetute nel tempo comparate con le caratteristiche anemografiche, la morfologia e i processi connessi con lo sviluppo delle piattaforme litorali lungo la costa nord-occidentale dell'Istria, tra Muggia e Pirano. Le ampiezze delle piattaforme locali, controllate in primo luogo dal fetch e dall'esposizione ai venti, variano da un minimo di 20 m nelle baie a 80 m in prossimità dei promontori. Il presente lavoro, lungi dall'essere esaustivo, vuole rappresentare un punto di partenza nella comprensione delle piattaforme costiere locali. L'erosione della piattaforma sembra essere il risultato dell'alterazione subaerea, nelle parti più elevate della piattaforma, dell'alterazione biologica, che alternativamente può proteggere o attaccare il Flysch intertidale e delle onde, le quali esercitano un'azione abrasiva sul substrato roccioso, non direttamente, ma grazie ai sedimenti in carico.*

**Parole chiave:** Piattaforme costiere, coste dell'Istria, Adriatico, falesie

## INTRODUCTION

The Holocene transgression gradually brought the sea to its present level, so for 6,000 years, marine and subaerial processes have been working on the shoreline, to create shore platforms. Trenhaile (2001) uses the term "shore platform" to refer to erosional surfaces within the actual intertidal zone, and the term "continental shelf" to the surface extending underneath. He suggests (Trenhaile, 1989, 2001) that subtidal surfaces are much wider when sea level is rising. Sorensen (1968) suggests the lowering of the sea floor is extended far below the surf base, therefore a part of the subtidal rocky shelf could currently be influenced by wave erosion. For this reason it is difficult to define a precise borderline between the actual and the relict bench. In this paper I use the term "subtidal rocky shelf", rather than "continental shelf" to distinguish the "wide rocky bench", showing ancient platform morphologies, from the sandy lower continental shelf.

Along the north-western Istrian coasts there are more than 15 kilometers where wide shore platforms occur, but morphodynamics and evolutive factors of platform development are not fully defined. Thus, purely descriptive terms, such as "shore platform", is preferable (Bird, 1976; Pethick, 1984; Trenhaile, 1987), rather than terms such as "abrasion terrace", always used in local literature, the latter including a genetic connotation (Sunamura, 1992).

Since Flysch is a relatively attachable rock-facies, there are only examples of sloping platforms along the north-western Istrian coasts, without a marked seaward drop (Type B; Sunamura, 1983). This type of platform generally grows with cliff recession; Flemming (1965) describes the first mathematical model, with stable sea level, in which his results were not in accord with the equilibrium theory. Sunamura (1978a) indicate that a platform grows if waves at the cliff foot have sufficient force to cause cliff recession, and stops when the wave assailing force becomes equal to the resisting force of the cliff. When the coastal rock is weaker, if the other factors remain constant, the platform becomes wider and flatter. But these models assume that there is no amount of debris supplied from the cliff and that no subaerial weathering occurs. Bedrock lowering, too, is important in platform development. Bartrum (1916, 1938), Wentworth (1938, 1939), Hills (1949) and Stephenson & Kirk (1998, 2000a, b) support weathering as the formative process, while Dana (1849), Bartrum (1924, 1926), Edwards (1941, 1951), Sunamura (1978b), Trenhaile (1987), Tsujimoto (1987) and Sunamura (1990) support wave action. So, Stephenson & Kirk (2000a) speak about the "wave vs. weathering" debate. Understanding these factors is important for the study of ancient and recent evolution of the coast.

This paper aims at providing an overview of the shore platforms along the north-western Istrian coast, at describing their morphology and development, by using morphological analysis. The results of this work were presented, some months ago, in the public debate "*Quanto vale la costa di Muggia*", in which the impact of the landfill project in Punta Sottile and the opportunity to create a Coastal Reserve from Punta Sottile to Debeli Rtič were evaluated.

## MATERIAL AND METHODS

## Study area

The north-western Istrian coasts are located in the Gulf of Trieste, on the east coasts of the North Adriatic Sea (Fig. 1). The area involves about fifty kilometers of partly natural shoreline, with about 15 km of shore platforms, and partly human-built shoreline, characterized by the presence of coastal roads, sea walls, landfills and towns.

Geologically, the area belongs to the so-called Grey Istria (Ambert, 1978). Its name derives from the presence of the thick Eocene flysch, consisting of interbedded sandstones and marlstones and carbonate turbidites, with ratio bed thickness changing irregularly (Pavšič & Peckmann, 1996).

Tidal range in the North Adriatic Sea is typically in the order of 1 m, one of the highest in the Mediterranean Sea, but, in particular meteoroclimatic conditions, water sea level can rise to 2 m m.s.l. Mean sea level is lower during the winter (4 cm), spring and summer (1 cm), and higher during the autumn (5 cm) (Stravisi, 1988).

Precipitations average about 1,341 mm per year with the highest rainfall observed during June and November (<http://www.dst.univ.trieste.it/OM/OM.html>).

The northern Adriatic Sea is a shallow basin (mean depth ~20 m), so high frequency waves are quite modified by sea floor and the wave breaking occurs away from the shore, with high loss of energy. Generally, the area is quite protected from waves of the second and third quadrants, with predominant wind directions from northeast, then southeast and northwest. The windiest months are February and October (Stravisi, 1991). The strong northeast winds (*bora*) can produce 2 m high waves in the southern part, particularly at Piran and Rt Ronek. South-eastern waves, 20-50 m long, arrive reflected, but they are not more than 1 m high (Mosetti, 1988). Only sporadic *libeccio* (SW) causes 3.4 m high waves and affects particularly the south-western coast of Debeli Rtič and Punta Sottile, even though there are no high waves due to the limited fetch (Mosetti, 1988).

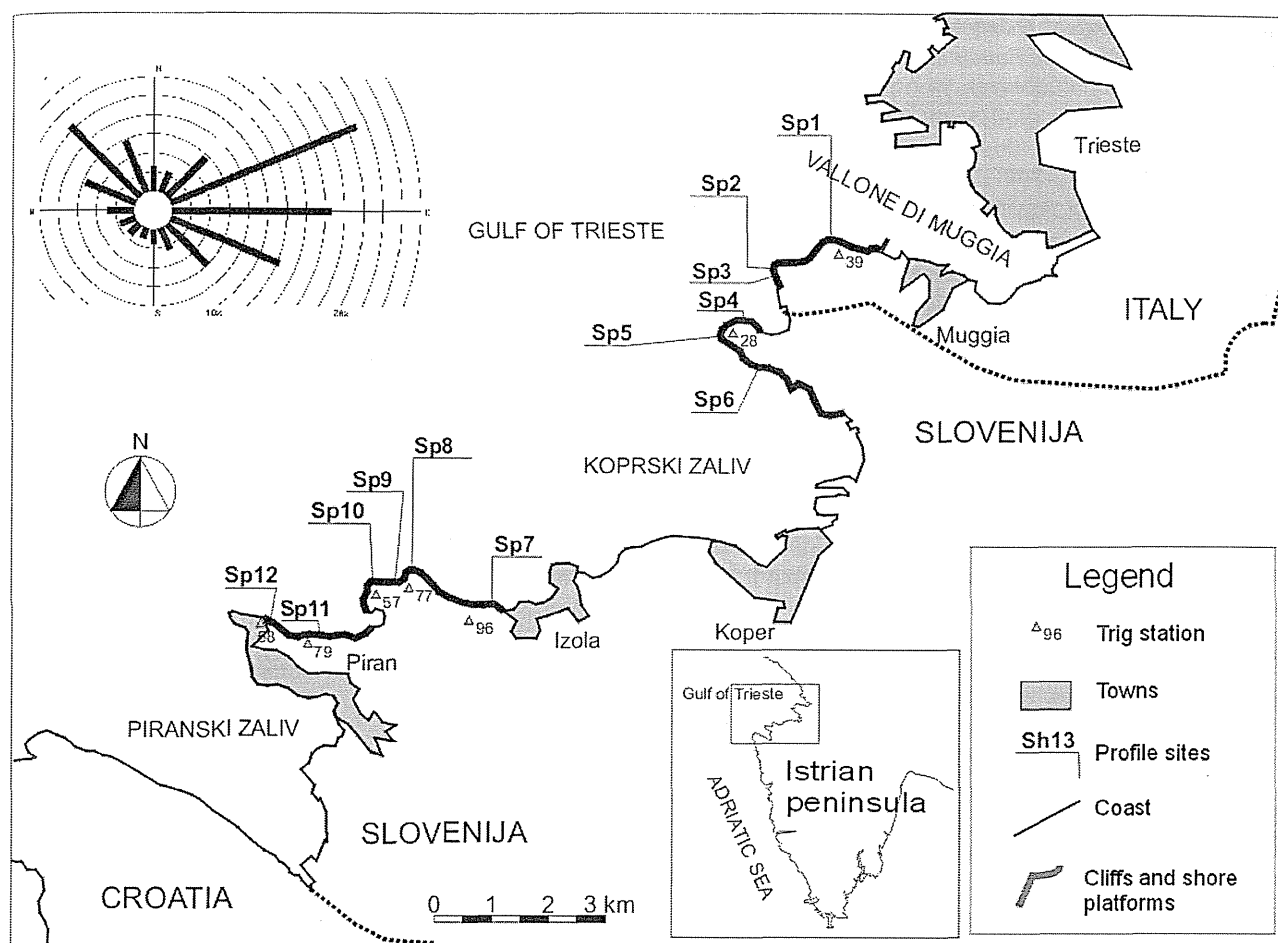


Fig. 1: The north-western Istrian coast, town names and profile sites.

Sl. 1: Severozahodno istrsko obrežje, imena mest in vzorčevalni profili.

### Material and methods

Along the Italian and Slovenian shores, twelve sites (Fig. 1) were surveyed in the period between June 2001 and June 2003. Six of the sites are located in the northern sector, between Punta Olmi and Debeli Rtič, and six in the southern sector, between Rt Kane and Piran. Surveys were carried out with the Automatic Level Ertel (Salmoiraghi) to measure elevation and with a rule to measure lengths. Then, profiles were controlled by SCUBA recognition. Some profiles were corrected with tide because of the distance of a trigonometric station. Three profiles, in the Italian sector, were extended offshore with the Echosounding Lowrance X16 operated from a boat.

### RESULTS AND DISCUSSION

Sloping platform width is defined as the area between the foot of the cliff and either the low tidal level or the position providing the surf base. We recognized

two types of sloping platforms: gently sloping platforms (Type A; Sunamura, 1992) and ramp platforms. The first type of platforms was identified at Sp5 and Sp9. These platforms are located off prominent headlands (Debeli Rtič and Rt Ronek) and display a platform width ranging from 70 to 80 m. They are exposed to the longest fetch length (up to 125 km). As Trenhaile (1999) suggests that platform width increases with wave intensity, I studied the correlation between maximum fetch length and platform width (Tab. 1). At Debeli Rtič and Rt Ronek, for example, the platform is really wide and the sites are exposed to the longest fetches. A good relationship between fetch and platform width was observed along the north-western Istrian coasts (Fig. 2). Allan *et al.* (2002) suggest that fetch length may be used as a surrogate for wave energy. Linear regression analysis reveals a positive correlation between fetch and width ( $r^2=0.63$ ). Data for Punta Sottile were not included in regression equation because of the presence of the coastal road, which restricts platform width.



**Tab. 1: Morphological characteristics of shore platforms along the north-western Istrian coast.****Tab. 1: Morfološke značilnosti obrežnih plosčadi vzdolž severozahodnega dela istrske obale.**

	Site	Strike/ dip (°)	Platform width (m)	Shore ori- entation (°)	Max fetch (km)	Notes
Sp1	Punta Olmi	120/45	26	345 NNW	48	Coastal road on the cliff/platform junction
Sp2	Punta Sottile	330/25	/	265 W	125	Coastal road on the cliff/platform junction
Sp3	Punta Sottile-WSW	320/55	28	245 WSW	125	Coastal road on the cliff/platform junction
Sp4	Debeli rtič-N	325/30	33	355 N	47	/
Sp5	Debeli rtič-SW	320/25	80	250 W	120	/
Sp6	Debeli rtič-SSW	295/12	35	200 SSW	120	/
Sp7	Rt Kane	115/40	20	360 N	42	/
Sp8	Rt Ronek	100/20	70	295 WNW	105	/
Sp9	Ronek-Strunjan	110/20	25	320 NNW	41	/
Sp10	Strunjan rtič	105/15	40	320 NNW	98	/
Sp11	Pacug-Fiesa	100/5	20	15 NNE	38	/
Sp12	Piran	90/10	22	35 NNE	39	/

Ramp platforms have been identified in many sites. They have a steep sloping profile and are found on long straight shores and in embayments. Because of their high gradients, they are narrower than gently sloping platforms.

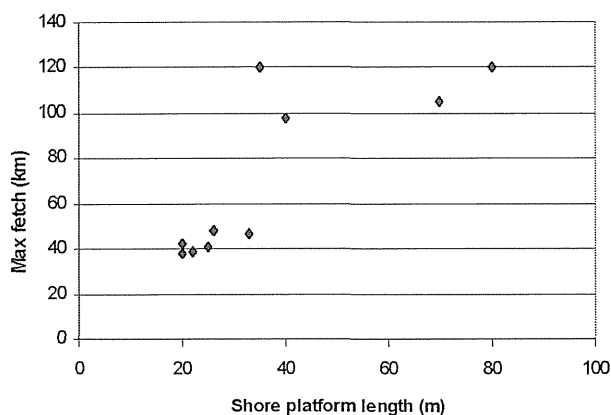
Inside these two types of platforms, it is possible to recognize a high platform, a "normal intertidal platform" and a low platform. The high platform, near the cliff/platform junction, is barely covered by maximum high tides, the normal intertidal platform is alternatively covered and uncovered by normal tides and the low platform is uncovered only during minimum low tides. At higher elevations, sub-aerial weathering dominates the erosion processes, while slope wash processes remove the weathered debris and transport the material seaward, on the low platform. In the "normal intertidal platform" there is a great incidence of wetting and drying weathering, but also of wave abrasion, due to the action of waves armed with rock particles. These waves

hit the bedrock and remove material. Freeze/thaw weathering is not important as temperature is rarely less than 0 °C. In the period between December 2002 – February 2003, temperature reached –3.5 °C. Laboratory simulations (Robinson & Jerwood, 1977) indicate that destructive freezing occurs only when the internal rock temperature drops below –4.5 °C.

#### Shore platforms from Muggia to Lazaret

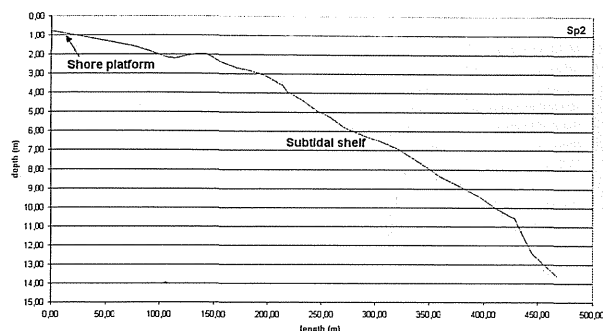
The Muggia peninsula is elongated NW-SE and is characterized by different fetch orientation. From Muggia to S. Bartolomeo the cliff/platform junction is characterized by a coastal road and some harbour structures (Muggia, Porto S. Rocco, Lazzaretto), so actual shore platforms are really narrow. At Punta Olmi (Sp1), there is a cobble beach with trash from coastal road construction (Brambati & Catani, 1988). The shore platform is 26 m wide, with a *Cymodocea nodosa* carpet within sandstone boulders on the lower part; from Punta Olmi to Punta Sottile it is completely hidden by the coastal road and by the recent landfill. Moreover, in Punta Sottile, because of the coastal road, actual bench is narrow or not present, but there is a wide subtidal rocky platform. From Punta Sottile to Piran this surface is really wide, up to 4-500 m (Figs. 3, 6). This surface is characterised by wide sandstone bedrock, sometimes horizontal or nearly horizontal, sometimes dipping NE, and sometimes covered with abundant debris. This outcrop looks like a man-made pavement, the so-called "Roman pavement" (Furlani & Frenopoulos, 2003). Rock debris ends at about 9 m depth, where sand deposition starts.

From Punta Sottile to Lazzaretto, the shore platform is about 30 m wide (28 m in Sp3). Because of the coastal road, only during low spring tide the actual platform is dry (Fig. 4). It is partially covered by clastic



**Fig. 2: Correlation of fetch versus shore platform width.**  
**Sl. 2: Razmerje med dolžino in širino obalne ravnice.**

sand with *Cymodocea nodosa* within a series of sandstone outcrops, dipping NE, down to 3.50 m depth. Along Punta Sottile and Debeli Rtič shoreline, there are many Roman structures (Gobet, 1983; Župančič, 1990).



**Fig. 3: Profile site Sp2 at Punta Sottile. The shore platform is visible only during the lowest tides, but down to depth of 10.5 m there is a wide subtidal rocky shelf.**

**Sl. 3: Profilna lokacija Sp2 na Puntji Sottile (Tenki rtič). Obrežna ploščad je vidna le med najnižjo oseko, čeprav se široka podbibavična skalna polica razteza do globine 10,5 m.**

#### Shore platforms from Lazaret to Ankaran

At Debeli Rtič, three profile sites show different platform width, according to maximum fetch and wind exposure. In profile Sp4, facing north, shore platform width is 33 m, with a maximum fetch of 47 km. This site is exposed to quadrant I and II. Sp5 is exposed to quadrants I, II and IV. Maximum shore platform width is about 80 m (Fig. 5) and a wide subtidal shelf is visible on aerial photographs. Cliff/platform junction varies from 0.3-0.4 m to more than one-meter m.s.l., with the lowest elevations being scratched by waves during most of the high tidal cycles. A 6.3 m wide cobble ramp links the cliff and the platform. Debris at the cliff toe is 6.3 m wide. Shore platform is partially covered by clastic sand with seagrass (*C. nodosa*) which, together with organic crust, protects the platform from erosion. Most of the shore platform remains below mean sea level, except during the lowest tides (Fig. 7). From 45 m to 80 m there is a vast pebble shoal, lightly rounded, resulting from storm-wave diffraction. From 80 to 100 m, sandstone beds, dipping NE, are covered by terrigenous/ bioclastic cobbles, while marlstone beds are easily exposed to destroying organisms.

In places where cliff/platform junction is low, particularly in the northern exposed sectors, storm waves attack materials at the foot of the cliff very quickly, allowing the formation of interesting cliff morphologies (notches and nips). In the northern sectors between Debeli Rtič and Strunjan Rtič, there are small notches. At Debeli Rtič, the roof of the notch is 2.8 m m.s.l., 2 m

high and 15 m long. Longitudinal section follows the bed's strike. The permanent photographic station controls notch and platform development. During the period from June 2001 – June 2003, debris at the cliff base was produced mainly by cliff falling, whereas storm waves removed the debris. The bedrock is alternatively covered with sediment of various sizes or exposed to wave attack and weathering (Fig. 8), thus the depth of sediment cover becomes an important factor for bedrock erosion. In fact, during the rainy period debris is removed seaward to the low platform, while NE winds store up cobbles on the higher platform, thus protecting it from bedrock lowering. Waves seem to be very important to move sediment along the platform and, even though they are not capable to produce erosion, waves can move cobbles and pebbles on the bedrock with abrasive action.

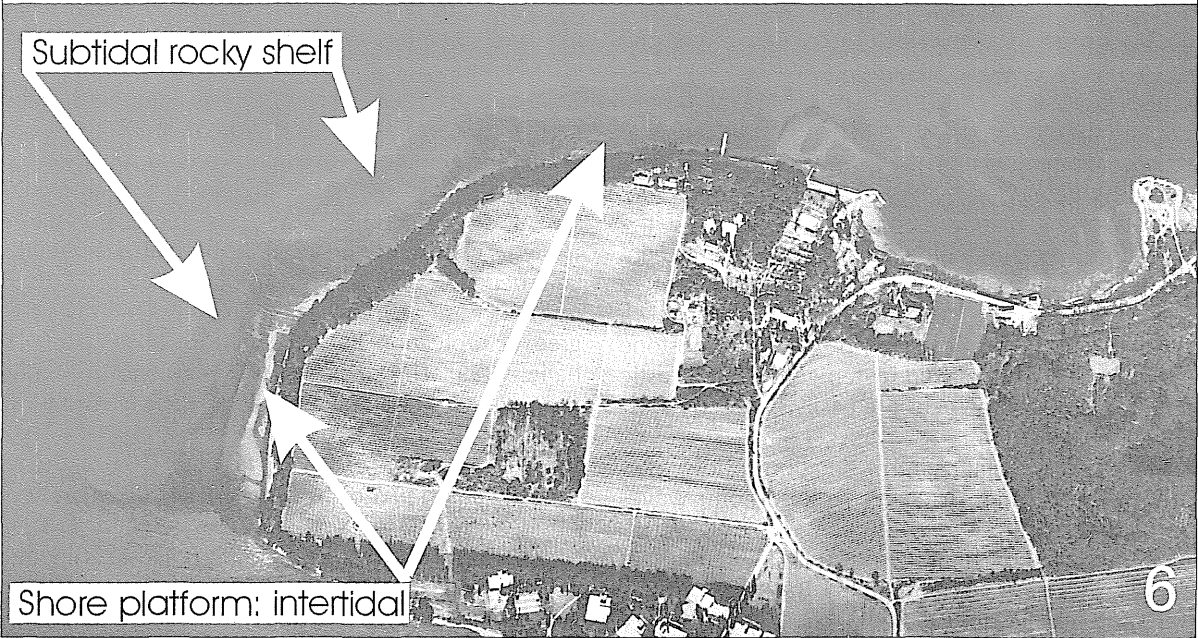
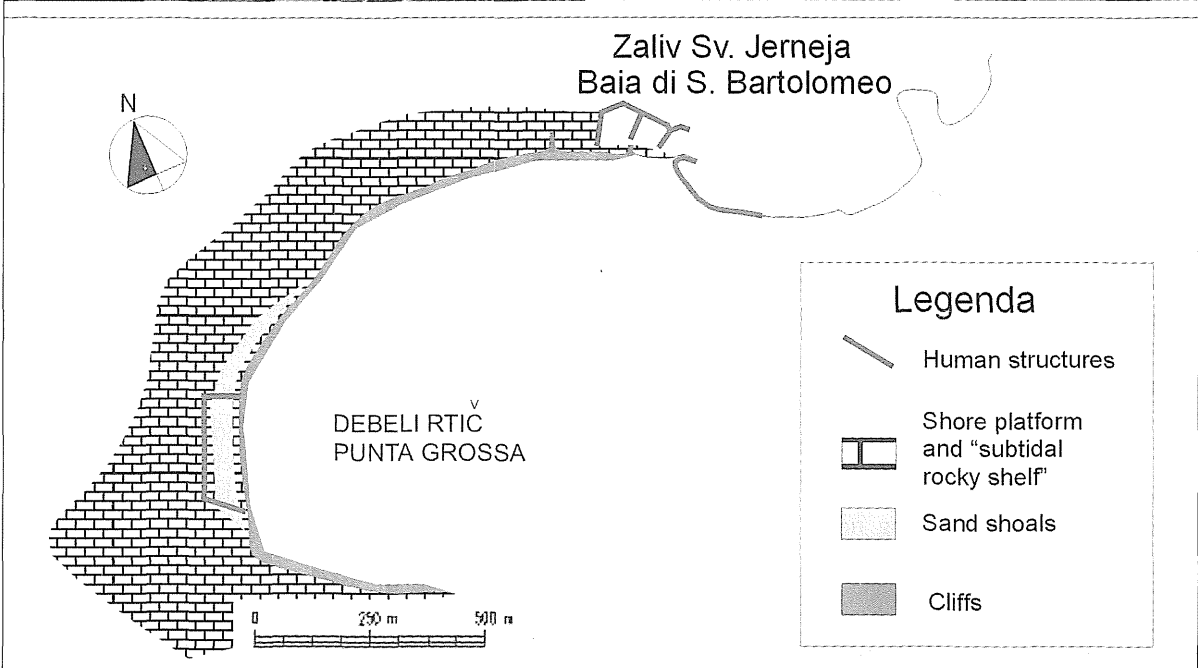
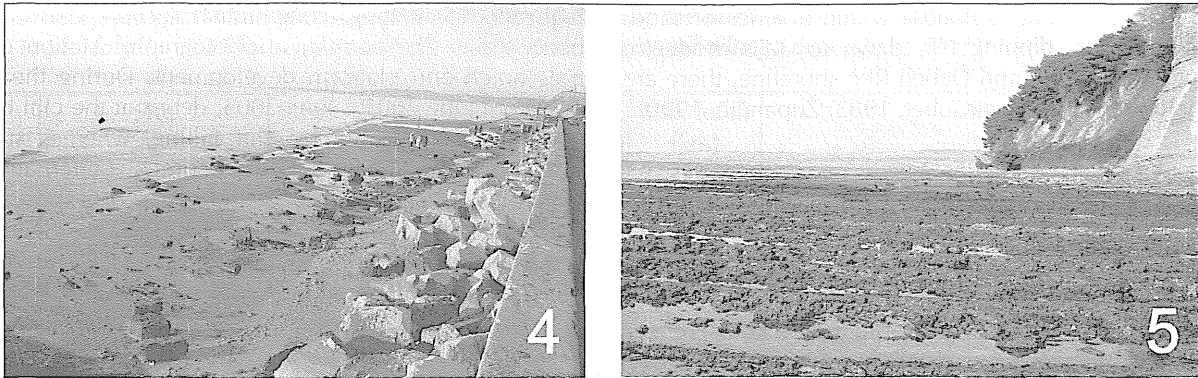
The north-western shoreline of Debeli Rtič is treated as a human structure, parallel to the shoreline, 71 m from the cliff/platform junction, -0.8 m m.s.l. The structure is about 200 m long, maybe built by the ancient Romans. It protects near-shore from wave attacks, so behind this structure there is a wide intertidal sand shoal. Here, cliff/platform junction is high and the cliff is particularly protected, allowing for the growth of abundant vegetation.

Along the south-western sector, the platform is 35 m wide. It has a long maximum fetch, but it is fairly well protected by the dominant winds of the quadrants I and II, thus only during SW and NW and SE storms it is attacked by waves. Between June 2002 – June 2003, waves attacked through this cliff only twice (16.11.02 and 07.12.02). Cliff is less hanging and cliff/platform junction is protected by a cobble beach of various sizes. Recession, in fact, is mainly due to subaerial weathering, and since this sector is not exposed, waves do not easily remove materials.

Along the coastal belt of Debeli Rtič, north cliffs are generally more hanging and shore platform has a narrow ramp, while south-western cliffs are fairly lofty and less hanging; moreover the ramp, linked to debris size, is wider. Robinson (1977) suggests that wider platforms develop with sandy beaches at the cliff base, then with bare bedrock, boulder and talus cone, since the mobility of the deposits of the foot of the cliff determines the degree of protection and the amount of abrasion (Trenhaile, 1999). The size of clastic sediments on the beach depends on the thickness of sandstone beds of the eroding cliff face.

#### Shore platforms from Izola to Strunjan

Between Simonov zaliv and Strunjanski zaliv there is a 5 km long cliffy coast, bordered by shore platforms. The subtidal rocky shelf is very wide from Izola to Piran, down to 10 m deep. Cliffs are high (up to 90 m m.s.l.,



**Fig. 4:** At Punta Sottile, the shore platform is visible only during the lowest tides, as the coastal road has been built on the shore platform. (Photo: S. Furlani)

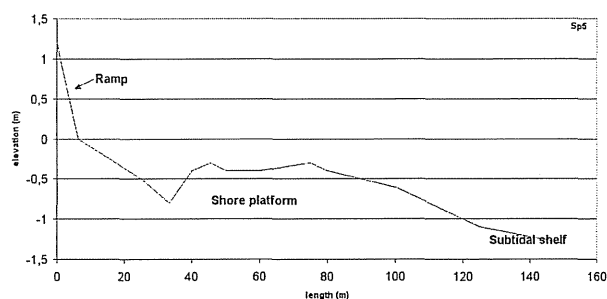
**Sl. 4:** Pri Punt Sottile (Tenki rtič) je obrežna ploščad vidna le med najnižjo oseko, saj je bila na platformi zgrajena obalna cesta. (Foto: S. Furlani)

**Fig. 5:** The gently sloping platform at Debeli rtič (15.04.03). The bench consists of bands of sandstone, which outcrop seawards from the cliff base (right). Marlstone interbeds are lower in elevation because of their low resistance and form a sort of channels, sometimes filled with cobble. (Photo: S. Furlani)

**Sl. 5:** Rahlo spuščajoča se ploščad pri Debelem rtiču (15.04.03). Terasa sestoji iz pasov peščenjaka, ki prihajajo na dan v smeri morja iz klifovega podnožja (desno). Laporjeve medplasti, ki zaradi svoje nizke odpornosti ležijo nižje, oblikujejo nekakšne kanale, ki so včasih zasuti s prodniki. (Foto: S. Furlani)

**Fig. 6:** Aerial view and map of Debeli rtič. It is difficult to define a precise borderline between the actual shore platform and the subtidal rocky shelf due either to the morphological continuity or to the fact that the lowering of sea floor is extended far below the surf base. (By courtesy of Regione Autonoma Friuli Venezia Giulia)

**Sl. 6:** Zračni posnetek in zemljevid Debelega rtiča. Zaradi morfološke kontinuitete ali pa dejstva, da se morsko dno počasi znižuje, je težko ugotoviti natančno mejo med dejansko obrežno ploščadjo in podbibavično skalnato polico. (Z dovoljenjem avtonomne regije Furlanija-Juljska krajina)



**Fig. 7:** Profile site Sp5 at Debeli rtič. Diffraction of waves has created a wide cobble shoal.

**Sl. 7:** Profilna lokacija Sp5 pri Debelem rtiču. Lomljenje valov je povzročilo široko prodnato plitvino.

very steep off the headlands and gently sloping in the embayments. In Rt Kane the cliff/platform junction is characterised by a thick sandstone bed (more than 1 m) dipping SW. Shore platform is narrow and sandstone blocks protect the cliff base, either for their thickness or for dip and strike. Trenhaile (1999) suggests that platform width decreases with increasing rock dip, but in this case it is quite difficult to evaluate this relation as the most resistant sandstone strata are very thick, thus thickness is more important to protect the cliff base than rock dip.

Between Rt Kane and Strunjan there are four small embayments. I observed that platform deposits were larger in debris size with angular cobbles on the east sides of these bays, and smaller and rounded on the west sides. Past Rt Ronek, seagrass gradually disappears. Between Rt Kane and Rt Ronek, as well as between Rt Ronek and Strunjan Rtič, there are some turbidite beds, like a rampart, which border on actual shoreline (Fig. 9) or cut platforms transversally. Along the shoreline there are some interesting travertine boulders. At Rt Ronek, the actual platform width is 70 m. This gentle sloping platform is similar to Debeli Rtič (Sp5). A narrow ramp,

wider than at Debeli Rtič, connects the cliff base with the platform. In the east sector, there is a Flysch bedrock, in which less resistant marlstone strata, always exposed to destroying organisms, produce channels between more resistant sandstones, so marlstone beds are wetter than sandstone beds.

### Shore platforms from Strunjan to Piran

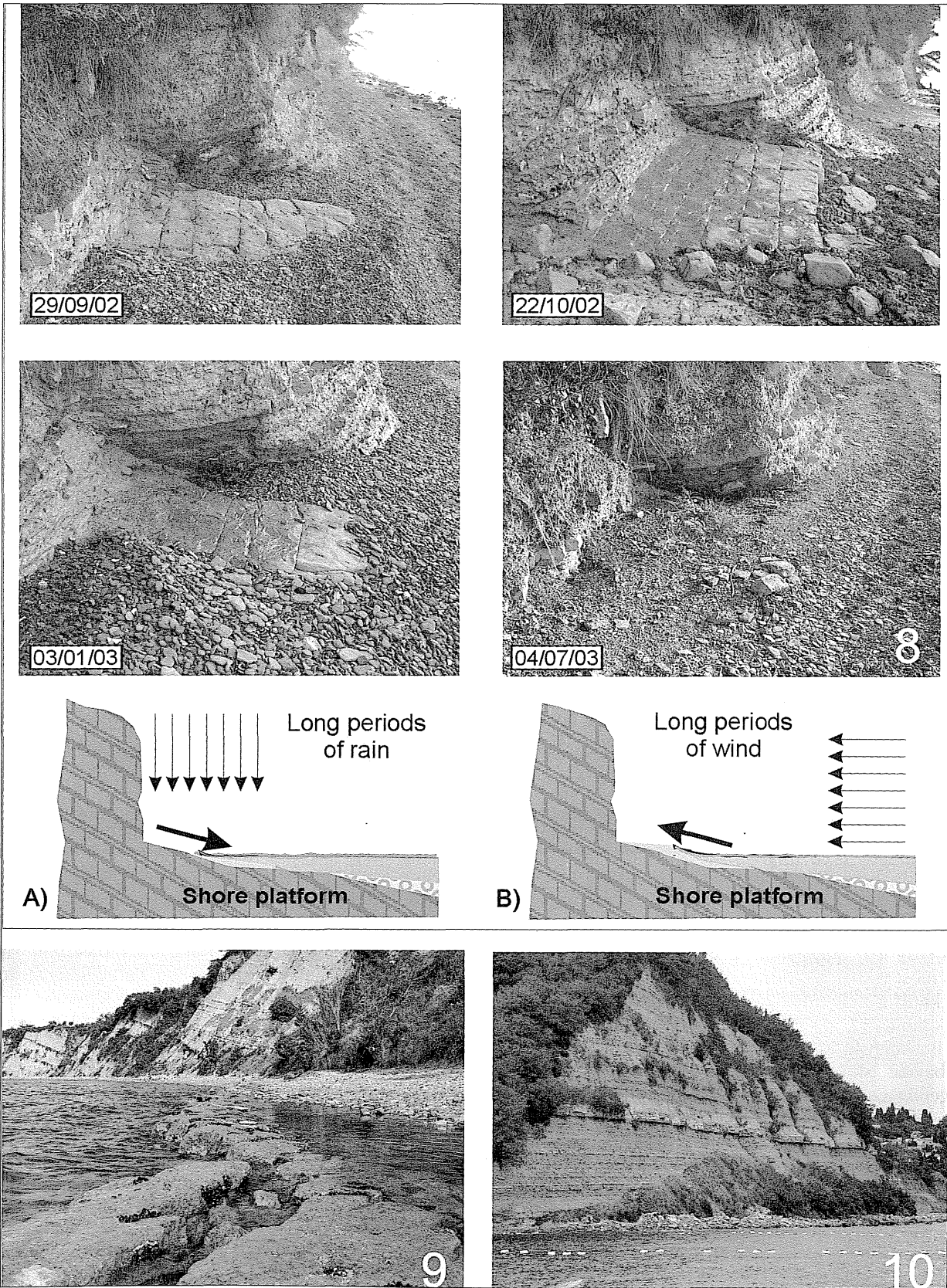
In this sector, only ramp platforms occur. Cliffs are up to 79 m high and between Strunjan and Fiesa, cliff/platform junction is hidden by turbidite boulders, originated from a metric turbidite layer, about 20 m m.s.l., on the bordering cliffs (Fig. 10). These boulders are particularly abundant along Pacug – Fiesa and protect the cliff. Flysch strata are near horizontal. The shore platform is narrow (20 m), chiefly because boulders do not allow materials to be removed. Only if there is a lack of boulders, storm waves reach the cliff base and remove the debris, otherwise the bedrock is completely hidden.

Between Fiesa and Madona Rtič, the shore platform is quite narrow, about 25-30 m. Part of the coastal belt is adjoined by a path, built on the shore platform. Cliffs are quite hanging without debris toe. Particularly narrow is the shore platform in front of the Church of St. George's walls in Piran.

### CONCLUSIONS

The north-western Istrian shore platforms are features neglected by local researchers, despite their great importance in understanding the actual morphodynamics, sea level rising etc. Along these shores two types of morphologies have been identified: gently sloping platforms and ramp platforms, characterized by widths ranging from 20 to 80 m, with the gently sloping platforms having the widest morphologies. Platforms are particularly wide in front of the headlands (Debeli Rtič,





**Fig. 8: Station PG1 at Debeli rtič:** The bedrock is alternatively covered with sediment of various sizes or exposed to wave attacks. During rainy periods, debris is removed seaward, while NE winds store up cobbles on the higher platform. (Photos: S. Furlani)

**Sl. 8: Postaja PG1 pri Debelem rtiču.** Matični substrat izmenično prekrivajo usedline različnih velikosti ali pa je izpostavljen butanjem valov. V deževnih obdobjih naplavine odnese proti morju, medtem ko severovzhodni vetrovi prestavijo prod na višjo ploščad. (Slike: S. Furlani)

**Fig. 9: These turbidite beds border on the actual shoreline between Rt Ronek and Strunjan rtič.** (Photo: S. Furlani)

**Sl. 9: Te turbiditne plasti mejijo na obrežje med Rtom Ronek in Strunjanskim rtičem.** (Foto: S. Furlani)

**Fig. 10: Between Pacug and Fiesia the shore platform is narrow, chiefly because boulders do not allow the materials to be removed.** (Photo: S. Furlani)

**Sl. 10: Obrežna ploščad med Pacugom in Fiesio je ozka, predvsem zato, ker kamniti bloki preprečujejo odstranitev različnega materiala.** (Foto: S. Furlani)

Rt Ronek as well as the wide subtidal shelf of Punta Sotile), mainly because of fetch and wind exposure, in fact relationship between fetch and platform width suggests a positive correlation. Moreover, owing to the morphological continuity, it is really difficult to find a limit between the actual platform structure and the subtidal rocky shelf.

Platform erosion seems to be the result of different processes: 1 – subaerial weathering, particularly on the higher platform and on the normal intertidal platform (wet/dry cycles); 2 – biological weathering, which alternatively protect and attacks bedrock; 3 – wave action, which directly do not exert an erosive action, but exert abrasion by removing cobbles and pebbles.

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## OBREŽNE PLOŠČADI VZDOLŽ SEVEROZAHODNEGA DELA ISTRSKE OBALE: PREGLED

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Avtor na osnovi ugotavljanja širine ploščadi in večkratnih morfoloških opazovanj, primerjanih z anemografskimi značilnostmi, v članku raziskuje morfologijo in procese, ki zadevajo razvoj obrežnih ploščadi vzdolž severozahodne istrske obale med Miljami in Piranom. Širina ploščadi, ki je odvisna predvsem od izpostavljenosti valovanju in delovanja vetra, se je sukala med 20 m v zalivih do 80 m ob rtičih. S pričujočo študijo, ki seveda ni izčrpna, želi njen avtor pripomoči k razumevanju lokalnih obrežnih ploščadi. Zdi se, da je erozija ploščadi posledica preperevanja nad gladino morja na višji ploščadi, biološkega preperevanja, ki izmenično ščiti in napada medbibavični fliš, in valov, ki ob odstranjevanju sedimentov delujejo abrazivno na matični substrat.

**Ključne besede:** obrežne ploščadi, istrsko obrežje, Jadransko morje, klifi

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## PRELIMINARY CHARACTERIZATION OF MAGMATIC CLASTS FROM CONGLOMERATE WITHIN THE BOVEC FLYSCH (SLOVENIA)

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### ABSTRACT

*A Maastrichtian conglomerate related to the flysch beds of the Slovenian sedimentary basin and outcropping near Bovec is characterized by the presence of rare magmatic clasts, basaltic in composition. Petrographical features and major elements composition allow us to classify the few collected clasts as lavas or sub-intrusive High Alumina Basalts, rocks commonly related to compressive movements involving the subduction of oceanic plate(s). Incompatible element patterns support the hypothesis of a compressive geotectonic setting and suggest involvement of a continental source mantle in the genesis of the magmatic clasts.*

**Key words:** conglomerate, Bovec, magmatic, HAB, Maastrichtian

## CARATTERIZZAZIONE PRELIMINARE DEI CLASTI MAGMATICI PRESENTI NEL CONGLOMERATO FLYSCHOIDE IN PROSSIMITÀ DI BOVEC (SLOVENIA)

### SINTESI

*Il conglomerato Maastrichtiano di Bovec rappresenta il primo importante episodio sedimentario clastico del Bacino Sloveno ed è caratterizzato dalla presenza di rari clasti magmatici basaltici di derivazione effusiva o sub-intrusiva. Le caratteristiche chimiche degli elementi maggiori e le evidenze petrografiche, tipiche dei basalti con un alto contenuto in alluminio, fanno ipotizzare, per i clasti finora campionati, un' unica genesi relazionabile ad eventi compressivi coinvolgenti la subduzione di placca oceanica. L'andamento degli elementi incompatibili supporta l'ipotesi di un ambiente geodinamico compressivo e suggerisce inoltre il coinvolgimento di una sorgente di mantello continentale.*

**Parole chiave:** conglomerato, Bovec, magmatico, HAB, Maastrichtiano

# INTRODUCTION

The presence of unaltered and unmetamorphosed magmatic clasts in terrigenous sediments, deposited before the paroxysmal orogenic events (*i.e.* Dinaric and Alpine orogenesis), could provide important information on the sub-lithospheric mantle.

The main objective of this study is to give a first characterization of the few volcanic rocks collected from a conglomerate inside the Maastrichtian flysch conglomerate near Bovec to provide eventual information on the possible mantle source(s) involved, to evidence the presence of one or more magmatic events and to give first information about their possible geodynamic formation setting.

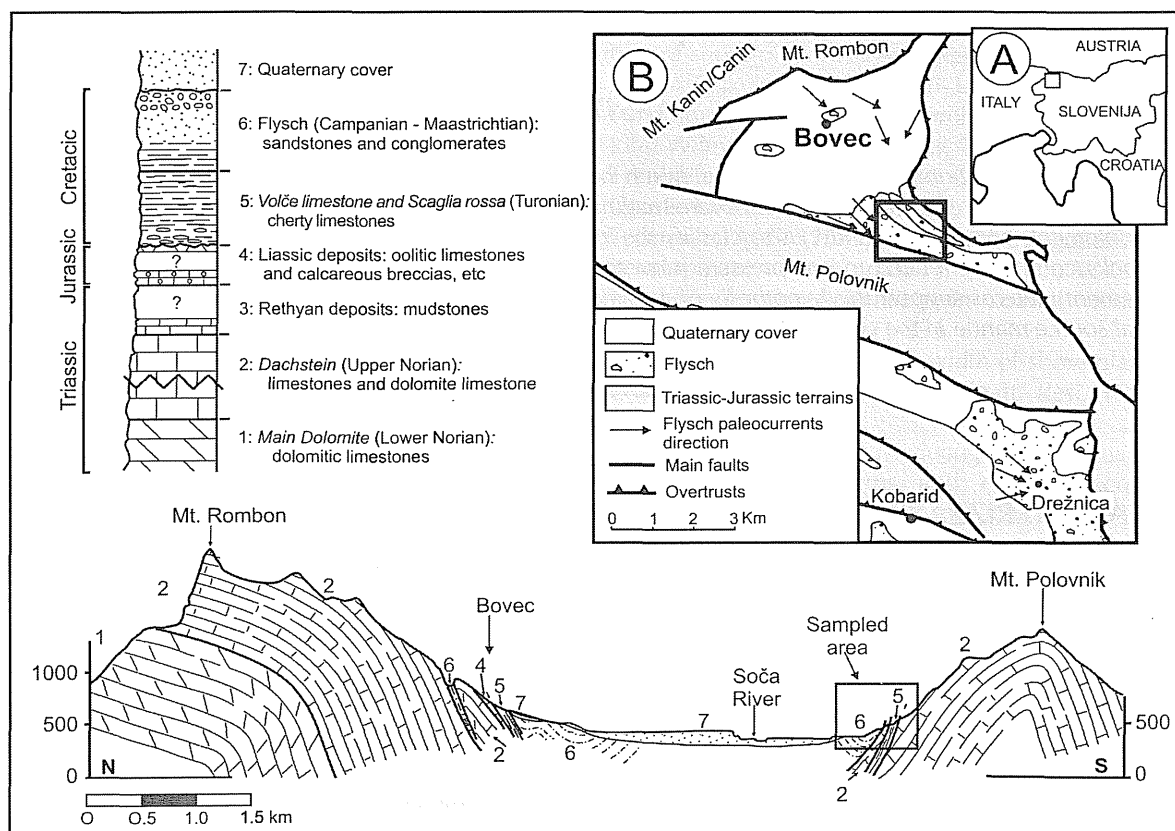
## Geological and stratigraphical outlines

Bovec is located in NW Slovenia (Fig. 1A), between Mt. Rombon and Mt. Polovnik.

The stratigraphic succession of the area began in the

Late Triassic (Lower Norian) with the very thick carbonate platforms of the "Main Dolomite" (dolomitic limestone) and "Dachstein" (limestone) formations originating on the Julian Platform (Buser, 1986; Ogorelec & Buser, 1996). These sequences are stratigraphically continuous with Rethyan successions represented by mudstones and limestones, typical of a neritic environment (Selli, 1947).

The Jurassic is represented by the Middle Liassic oolitic limestones (Buser, 1986; Jurkovšek *et al.*, 1988/89) and limestone breccias, the latter testifying an emersion of the area (Selli, 1947). The Julian carbonate platform was disintegrated in the Upper Lias due to compressive NE-SW movements, which led to a moderate and locally heavy folding of the area (Selli, 1947). In the surroundings of Bovec, there are typical dykes filled with red and grey crinoidal limestones. In the upper section, or at places directly on the Liassic neritic limestones, nodular limestones (Rosso Ammonitico) occur. Close to Bovec, manganese deposits, often in the shape of round manganese nodules, are occasionally present. During



**Fig. 1: Stratigraphic column of the stratigraphic section of Bovec basin with denoted position of studied conglomerate. A: Geographical location of Bovec basin; B: Sketch map showing the flysch outcrops (modified after Kuščer *et al.*, 1974 and Buser, 1974).**

**Sl. 1: Stratigrafski stolpec stratigrafske sekcije bovškega bazena z označenimi legami preučevanega konglomerata. A: geografska lega bovškega bazena; B: zemljepisna karta z vrisanimi flišnimi izdanki (prirejeno po Kuščer *et al.*, 1974 in Buser, 1974).**

the Early Jurassic, Mt. Polovnik probably rose, which acted as a barrier during the Cretaceous marine ingression occurred in the sector between the Bovec area, located to north, and the Kobarid area, located to south. In the studied area, Cretaceous sediments are represented by thin bedded calcareous turbidites with chert of carbonate turbidities (Ogorelec *et al.*, 1974) that gradually developed in siliciclastic turbiditic sediments (Bovec flysch) during the Campanian – Maastrichtian (Aubouin, 1963; Cousin, 1970; Kuščer *et al.*, 1974; Pavšič, 1994).

The present paper focuses on the conglomerates located at the top of the Bovec flysch (Fig. 1B). The clasts are mainly composed of Dachstein limestones, Rethyan-Liassic brown limestones, red and black chert limestones of "Scaglia rossa" and Volče limestone, dark limestones with Raiblian fossils, volcanic clasts, few metamorphic clasts of probably Permian age, and plagioclase-rich sandstones (Selli, 1947; Kuščer *et al.*, 1974; Venturini & Tunis, 1992).

## MATERIAL AND METHODS

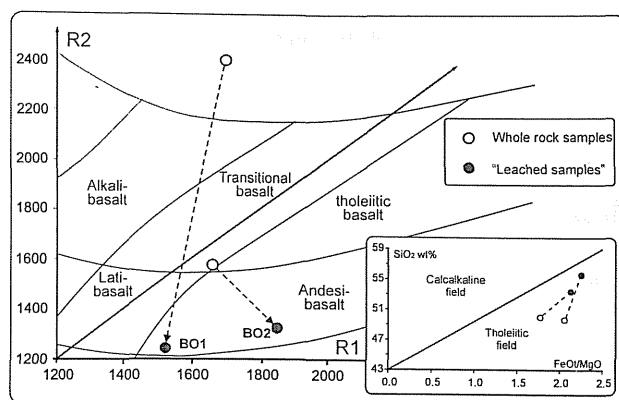
Diffraction analyses have been carried out at the "Dipartimento di Scienze della Terra" of the University of Trieste by means of powder diffractometer SIEMENS D500 (CuK $\alpha$  at 40 kV and 20 mA).

Major and trace element concentrations were determined using PW 1404 XRF spectrometer and the procedures of Philips<sup>®</sup> (1994) for the correction of matrix effects. Major element abundances were recalculated to 100 wt% on a volatile-free basis. The analytical uncertainties were estimated at less than 5% and 10% for major and trace elements, respectively. The samples have been analysed before and after the leaching procedure (Petrini *et al.*, 1987) in order to remove the secondary carbonates.

## RESULTS

### Petrographical features, classification and nomenclature

The volcanic clasts have main sizes diameter variable from 1-3 cm. The dimension of magmatic clasts and the roundness factor of carbonate and metamorphic clasts (roundness factor is not indicative for basaltic clasts, since their morphology is due to onion skin exfoliation) suggest a fluvial transport and a relative proximity to the erosion area. Petrographical analyses showed that higher glass contents recrystallized only partially into clay minerals. The texture ranges from subophitic-interstitial to microporphyritic. Rare feno- and microfenocrystals of an-plagioclase, augite, opaques and occasional olivines have been observed, secondary calcite plaques are often present. Due to the abundant plagioclase, these rocks have been optically classified as andesitic basalts.



**Fig. 2:** Distribution of the Bovec volcanic clasts in R1-R2 classification diagram of De La Roche *et al.* (1980) as modified by Bellieni *et al.* (1981). Inset: SiO<sub>2</sub> vs. FeO<sub>T</sub>/MgO diagram for basic sub-alkaline rocks (Miyashiro, 1974).

**Sl. 2:** Razširjenost bovških vulkanskih delcev v klasifikacijskem diagramu R1-R2 po De La Roche *et al.* (1980) in modificiranem po Bellieni *et al.* (1981). V okvirčku: diagram SiO<sub>2</sub> vs. FeO<sub>T</sub>/MgO za bazične subalkalinske kamnine (Miyashiro, 1974).

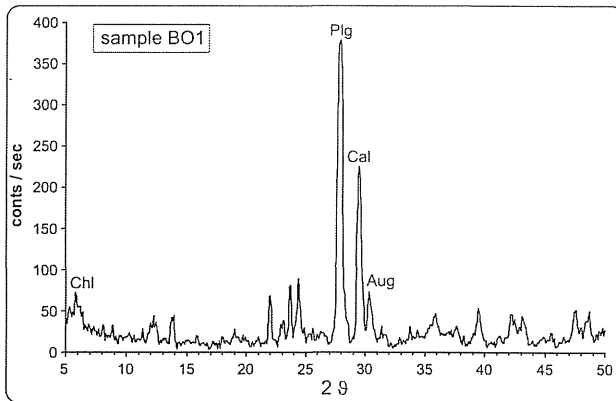
The studied samples have been classified (Fig. 2) according to De La Roche *et al.* (1980), and Bellieni *et al.* (1981). Note that after the leaching procedure all the samples plot in the Andesi-basalt field, are in agreement with their optical features. Finally, the samples fall (inset of Fig. 2) in the tholeiitic field for the SiO<sub>2</sub> – FeO<sub>T</sub>/MgO relationships (Miyashiro, 1974).

### Diffraction data

The analyses obtained from a representative volcanic clast (e.g. sample BO1; Fig. 3) revealed the presence of augite, plagioclase, calcite and minor clay amounts, supporting the optical features.

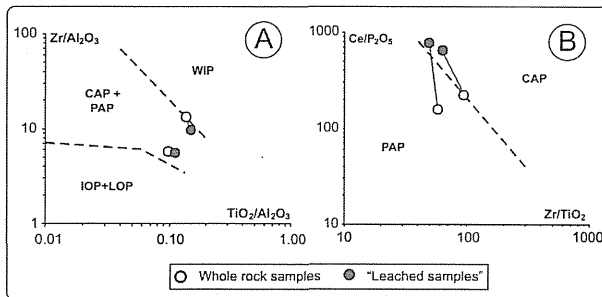
### Geochemistry

The CIPW norm has been calculated in dry conditions with Fe<sub>2</sub>O<sub>3</sub>/FeO = 0.15. Among the normative minerals, quartz (6-10 wt %), hypersthene (8-11 wt %), and occasional corindone (0-0.5 wt %) were present. These features, together with the high SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> (> 53 and > 18.5 wt %, respectively) and low MgO (< 4.5 wt %), associate the studied volcanics to the High-Alumina Basalt (HAB; James *et al.*, 1986), usually related to compressive geotectonic conditions (island-arc tectonic environment). These features contrast with the SiO<sub>2</sub> – FeO<sub>T</sub>/MgO relationships of Miyashiro (1974). The authors of the article believe that the scarcity of SiO<sub>2</sub> may possibly be connected with natural leaching due to the glass alteration in clay minerals and in colloidal phases.



**Fig. 3:** Diffractometric analyses of the BO1 sample (volcanic clast). Chl: chlorite; Plg: plagioclase; Cal: calcite; Aug: augite.

**Sl. 3:** Difrakometrične analize vzorca BO1 (vulkanski delec). Chl: klorit; Plg: plagioklaz; Cal: kalcit; Aug: avgit.



**Fig. 4:**  $Zr/Al_2O_3$  vs.  $TiO_2/Al_2O_3$  and  $Ce/P_2O_5$  vs.  $Zr/TiO_2$  tectonomagmatic diagrams (Müller *et al.*, 1992). CAP: Continental Arc; IOP: Initial Oceanic Arc; LOP: Late Oceanic Arc; PAP: Postcollisional Arc; WIP: Within Plate.

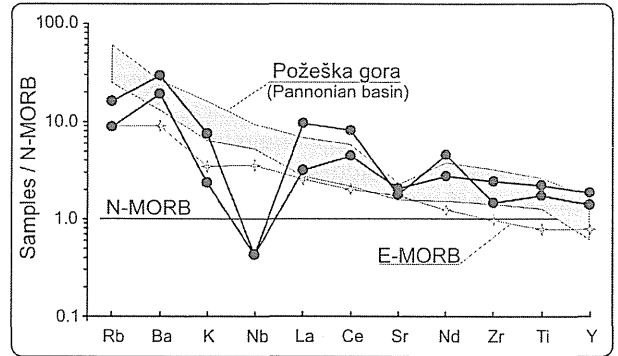
**Sl. 4:** Tektonomagmatska diagrama  $Zr/Al_2O_3$  vs.  $TiO_2/Al_2O_3$  in  $Ce/P_2O_5$  vs.  $Zr/TiO_2$  (Müller *et al.*, 1992). CAP: celinski lok; IOP: začetni oceanski lok; LOP: zadnji oceanski lok; PAP: pokolizijski lok; WIP: znotraj plošče.

In the tectonomagmatic diagram of figure 4A (Müller *et al.*, 1992), the selected samples plot into the orogenic field of continental - postcollisional arc basalts. After the leaching procedure (Fig. 4B; Müller *et al.*, 1992), the samples plot into the field of continental arc basalts.

Considering the trace elements, samples (Fig. 5) are characterized by strong negative Nb anomaly (indicative of crustal contamination or involvement of eclogitic layers in mantle source) and by a negative Sr anomaly (related to plagioclase fractionation). The collected samples show, except for the Nb anomaly, patterns and mean incompatible elements (IE) concentrations (Fig. 5) comparable with Upper Cretaceous - Paleogene tholeiitic basalts from the Pannonian basin (Belak *et al.*, 1988),

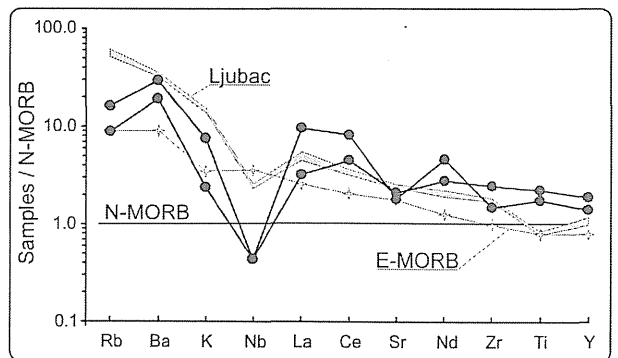
but differ from the Triassic basic magmatism (shoshonitic in composition) from the Alps (not shown).

The studied samples have now been also compared (Fig. 6) with the younger volcanics of Cenozoic age from Ljubac (Croatia; Lugović *et al.*, 1998), which are certainly related to the compressive geotectonic environment. These samples show patterns similar to the



**Fig. 5:** Incompatible element patterns of Bovec volcanic clasts normalised to N-MORB (Normal Middle Oceanic Ridge Basalt; Sun & McDonough, 1989). E-MORB: Enriched Middle Oceanic Ridge Basalt (Sun & McDonough, 1989); Požeška gora: Upper Cretaceous - Paleogene tholeiitic basalts of the southern margin of the Pannonian Basin (Belak *et al.*, 1988).

**Sl. 5:** Nezdružljivi vzorci elementov bovških vulkanskih delcev, normaliziranih na N-MORB (navadni srednjeoceanski grebenski bazalt; Sun & McDonough, 1989). E-MORB: obogateni srednjeoceanski grebenski bazalt (Sun & McDonough, 1989); Požeška gora: zgornja kreda - paleogenski toleitiški bazalti na spodnjem robu panonskega bazena (Belak *et al.*, 1988).



**Fig. 6:** Incompatible element patterns of Bovec volcanic clasts normalised to N-MORB. Ljubac: Late Cenozoic volcanics from the northern External Dinarides (Lugović *et al.*, 1998).

**Sl. 6:** Nezdružljivi vzorci elementov bovških vulkanskih delcev, normaliziranih na N-MORB. Ljubac: mlajše kenozojske vulkanske kamnine iz severnih Zunanjih Dinaridov (Lugović *et al.*, 1998).

studied volcanics including the Nb negative anomaly, but present lower mean IE contents for comparable grade of evolution.

### DISCUSSION

In general, the morphology of all clasts suggests that rivers probably supplied them and that the source area was probably quite close. As regards the magmatic clasts, they are quite scarce and their abundance does not appear compatible with a large volcanic apparatus closer than 100-150 km to the deposition area. Their frequency and petrographical features suggest that these clasts may be derived from the erosion of magmatic structures as sills or dykes. Actually it is impossible to attribute a certain age to the magmatic clasts, but chemical features suggest that they belong to a magmatic event related to an orogenic geotectonical setting.

Moreover, the trace elements indicate a source mantle enriched in incompatible elements with respect to the younger Cenozoic magmatism of the area. This suggests a more important involvement of a continental mantle source (in a compressive setting) comparable in many aspects with that of Pannonian volcanics.

### CONCLUSIONS

We can summarise the results as follows:

The studied magmatites are tholeiites one pyroxene-bearing (augites) characterized by subophitic-interstitial to micro porphyric texture.

The major elements associate the studied magmatites with the high alumina-basalts.

As far as the genesis of these tholeiites is concerned, the tectonomagmatic diagrams suggest a continental arc geodynamic environment.

The IE chemistry supports the major elements constraints and suggests involvement of a crustal component (crustal contamination or subducted eclogitic slab) in the tholeiites genesis.

Finally, the similitudes among the studied magmatites and those from the Ljubac and Pannonian basins suggest evolution of a common lithospheric mantle source.

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## PREDHODNA OPREDELITEV MAGMATSKIH DELCEV FLIŠNEGA KONGLOMERATA V BLIŽINI BOVCA

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### POVZETEK

*Avtorji so ob preučevanju redkih magmatskih, po sestavi bazaltnih delcev poskušali opredeliti maastrichtski konglomerat v povezavi s flišnimi plasti slovenskega sedimentarnega bazena, ki prihajajo na površje v bližini Bovca. Petrografske značilnosti in sestava iz poglavitnih elementov so jim omogočili, da so nekaj redkih zbranih delcev opredelili kot delce lave ali subintruzivnega bazalta z visoko vsebnostjo aluminija. Te kamnine so ponavadi povezane s kompresijskimi gibanji v subdukciji oceanskih plošč. Nezdržljivi vzorci elementov potrjujejo hipotezo o geotektonskem stiskanju in namigujejo, da je v nastanek magmatskih delcev vpleteno delovanje celinskega plašča.*

**Ključne besede:** konglomerat, Bovec, magmatski delci, HAB, Maastricht



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## THE ALLERGENIC FLORA OF TRIESTE (NE ITALY)

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### ABSTRACT

*In order to establish the allergenic flora of Trieste, aerobiological monitoring, clinical analysis and fieldwork were carried out at the same time. Using data from the medical and aerobiological literature, and on the basis of the data resulting from the local aerobiological and epidemiological monitoring, a selection of the over 1000 species recorded in the urban area was made to recognize the species locally inducing allergic diseases. The allergophytes growing in Trieste are 264, belonging to 26 allergenic families.*

**Key words:** aerobiological monitoring, allergenic flora, clinical data, pollen calendar, Trieste, Italy

## FLORA ALLERGENICA DI TRIESTE (ITALIA NE)

### SINTESI

*In parallelo al censimento floristico della città sono stati effettuati un monitoraggio aerobiologico ed un'analisi clinica al fine di conoscere la flora allergenica di Trieste. Durante il lavoro di campo sono state raccolte nell'area urbana oltre 1000 specie, poi selezionate per identificare quelle potenzialmente in grado di indurre manifestazioni allergiche da polline in sede locale. Tale selezione è stata fatta sulla base dei dati della letteratura medica e aerobiologica, dei risultati del monitoraggio pollinico dell'atmosfera di Trieste e di quelli derivanti dall'indagine clinica sulle pollinosi. Il contingente allergofitico della città risulta costituito da 264 specie appartenenti a 26 famiglie allergeniche.*

**Parole chiave:** monitoraggio aerobiologico, flora allergenica, dati clinici, calendario dei pollini, Trieste

## INTRODUCTION

Pollen with allergenic properties can induce pollenosis. The severity of the symptoms depends both on the amount of pollen grains occurring in the air and the sensitivity degree of the subject. The amount of the different pollen types occurring in the air varies greatly. Some pollen types are recorded only sporadically, others are always present in great amounts. Seasonal variations occur, depending on the flowering time of every species. Great variations in airborne pollen concentration are possible from year to year. Pollen from anemophilous species is usually the most relevant in inducing allergic disease due to high quantity in the air (D'Amato *et al.*, 2001). Grass pollen is the most common cause of pollenosis in Europe (Weeke & Spieksma, 1991). According to Jäger & D'Amato (2001), the most allergenic trees in Europe are *Betula*, *Olea* and *Cupressus*; of reduced allergenic significance are *Alnus*, *Corylus*, *Platanus* and *Castanea*. The most allergenic weeds are *Ambrosia*, *Artemisia* and *Parietaria*, while *Plantago*, *Chenopodium*, *Rumex*, *Mercurialis annua* and *Brassica napus* show minor allergological interest. Entomophilous species are scarcely significant in pollen allergy due to their low pollen amount in the environment, although they can be allergenic in subjects living in their proximity (Ariano *et al.*, 1991a). Isolated cases of occupational pollenosis have also been reported for some cultivated plants (e.g. Ariano *et al.*, 1991b; Garcia-Ortega *et al.*, 2001).

The aim of the present study is to draw up the allergenic flora of the town of Trieste. Aerobiological monitoring, clinical analysis and field work were carried out at the same time, in order to recognise, according to specific literature and on the basis of the data resulting from the local aerobiological and clinical monitoring, the town's allergenic flora.

## MATERIAL AND METHODS

## Study area

Trieste is situated on the coast of the North-Adriatic Sea and at the base of the Karst plateau. The town lies on clay and sandy rocks (Eocenic flysch) and deposited quaternary sediments, sited mainly along the coast. In the studied area, Euro-Siberian and Mediterranean vegetation coexist (Poldini, 1989). On the coast, hop hornbeam and holm oak scrub prevail, while the arenaceous hills around the town are rich with mixed mesophilous and thermophilous oak woods. On the outskirts of the town and in its urban area, anthropogenic and ruderal vegetation is common, due to the construction of buildings, roads, highways, and relating to industrial ducts and horticultural activities (Rizzi Longo & Martini, 2000).

## Aerobiological data

Airborne pollen was collected using a Hirst type 7-day recording volumetric spore trap (Burkard type) placed 20 m above the ground level at Bastione Fiorito of San Giusto Castle, in the town centre. The samples were collected, prepared, and analysed according to the standard method adopted by the Italian Aeroallergen Network (Mandrioli, 1990). On the basis of the most abundant airborne pollen grains recorded from 1996 until 1999, the pollen calendar for Trieste was constructed.

## Clinical data

Clinical analyses were carried out at the Department of Occupational Medicine between January 1<sup>st</sup> 1996 and December 1999 on 3,089 subjects of both sexes with allergic symptoms believed to be IgE mediated. The history of all the subjects was taken before clinical examination. Skin prick tests were performed with perennial allergens (house dust mites *Dermatophagoides pteronyssinus* and *D. farinae*) and pollens: Poaceae, Asteraceae, *Parietaria*, *Ambrosia*, Oleaceae, Corylaceae/Betulaceae, Cupressaceae and Platanaceae produced by Lofarma Allergeni, Milano. Skin reactions were read after 15 minutes using a millimetre rule. The reaction was compared to the size of a positive histamine control (10 mg/ml) and to a negative control (extraction solution without allergen), and was considered positive when the diameter was  $\geq 3$  mm. Symptoms were defined as seasonal when they were present only during certain months of the year, from January to October.

## Floristic data

The mapping project of the urban flora of Trieste, which began in 1992 (Rizzi Longo *et al.*, 1994) and ended in 2002, permitted us to implement about 48,000 floristic data. For this purpose, the urban area of Trieste (28 km<sup>2</sup>) was subdivided by a conventional grid into 282 Operational Geographic Units (OGUs), following the methods of the quantitative phytogeography (Ehrendorfer & Hamann, 1965; Crovello, 1981). The monitoring of the vascular flora was carried out in each OGU measuring 15" x 10" (about 325 x 307 m). Systematic nomenclature follows Poldini *et al.* (2001); life forms and chorological groups were detected from Poldini (1991) or Pignatti (1982).

## RESULTS

## Aerobiological data

The pollen calendar of the town is shown in Figure 1. In the calendar, the most frequent pollen types

monitored in the atmosphere of Trieste between January 15<sup>th</sup> and October 15<sup>th</sup> in the 1996-1999 period are listed in alphabetical order. These pollen types reach 85% of the year's total. The airborne pollen counts were expressed as pollen grains per cubic meter of air (p/m<sup>3</sup>). The pollen calendar was drawn using the four-year average of the monthly sums of the daily pollen counts. The quantitative intervals were selected to show the pollination peaks of the different pollen types. Very low monthly pollen quantities (<50 p/m<sup>3</sup>) or sporadically occurring pollen grains were not indicated.

As pointed out in previous papers (Rizzi Longo & Cristofolini, 1987; Rizzi Longo, 2002), pollen of trees prevails in the air of Trieste. The most common arboreal pollen types account together for 64% of the year's total. Particularly abundant are the pollen grains of Cupressaceae, reaching nearly one fourth of the year's total. Very great amounts of airborne pollen of Moraceae, almost all of *Broussonetia papyrifera*, are also present. Pollen grains from Corylaceae, Fagaceae, Oleaceae and Pinaceae are abundant. The higher monthly mean air concentrations for the indicated years are recorded in March for pollen from Cupressaceae (13,918 p/m<sup>3</sup>) and

in May for pollen from Moraceae (10,632 p/m<sup>3</sup>). Other pollen types show very lower monthly mean values.

Non-arboreal pollen types are less abundant. Only Urticaceae release great pollen concentrations in air, reaching globally almost one fifth of the year's total. Starting from March, the pollen counts of Urticaceae, mostly due to *Parietaria* pollen grains, increase quickly, reaching their peak in May (5,468 p/m<sup>3</sup>) and remaining high during the entire summer. Pollen from Poaceae is abundant, too, but the monthly amounts are lower. The pollen shedding of Poaceae is long, beginning in April, peaking in May (1,216 p/m<sup>3</sup>) and decreasing after September. Pollen grains from Asteraceae (mostly due to the pollen shedding of *Artemisia* and *Ambrosia*) and Chenopodiaceae/Amaranthaceae are less abundant, showing only in late summer enough great air concentrations, with peaks in August (679 and 128 p/m<sup>3</sup> respectively). Plantaginaceae and Polygonaceae (mostly *Rumex*) also show rather low pollen concentrations, the former occurring in spring/summer and peaking in July (203 p/m<sup>3</sup>), the latter having a significant occurrence (63 p/m<sup>3</sup>) only in May.

The pollen calendar of Trieste shows the occurrence

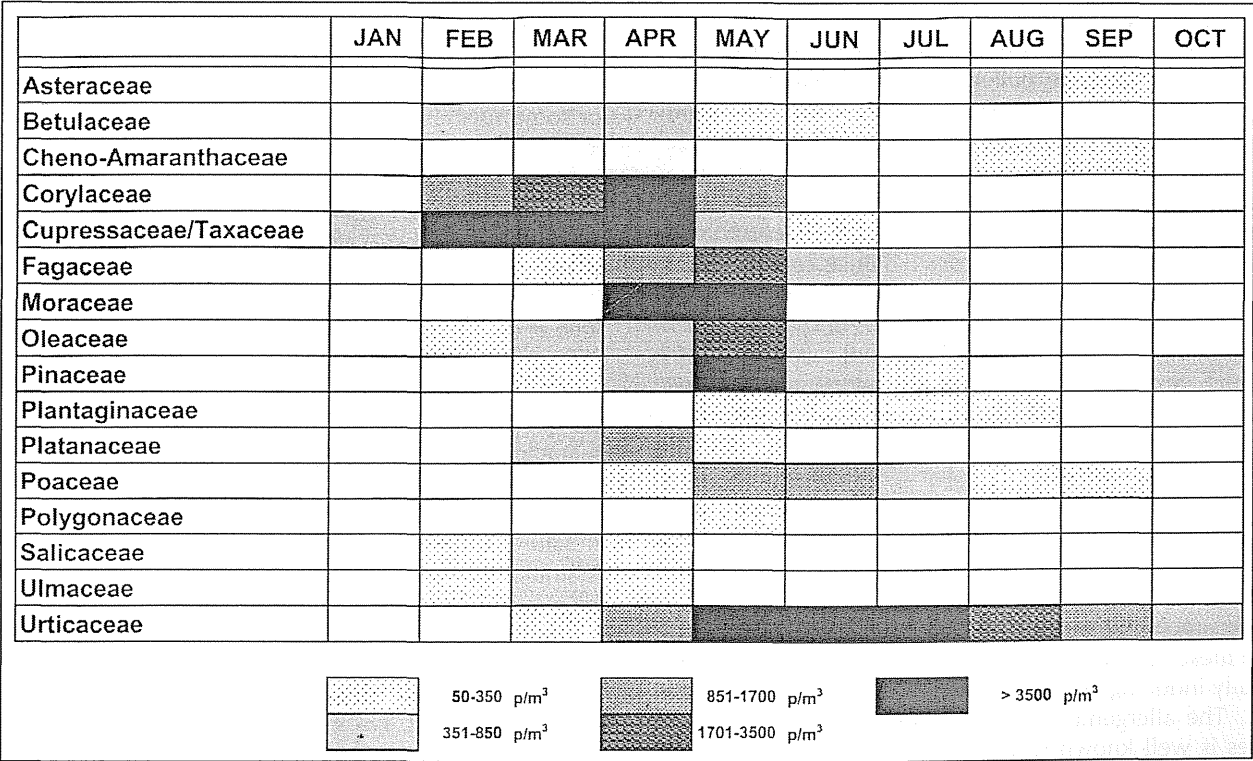


Fig. 1: Pollen calendar of Trieste. Only major airborne pollen types are represented. Monthly mean values from daily pollen counts are reported.  
Sl. 1: Tržaški pelodni koledar. Vključeni so samo poglavitni v zraku pojavljajoči se pelodni tipi s srednjimi mesečnimi vrednostmi njihovega dnevnega štetja.



of three pollen seasons: winter, spring, and summer. The winter season is marked by the highest pollen shedding from Cupressaceae/Taxaceae and by the increasing pollen values for Betulaceae (mostly *Alnus*), Corylaceae (mostly *Corylus*), Salicaceae, and Ulmaceae. The spring season shows the occurrence in the air of the more frequent pollen types; it is dominated by the highest airborne pollen values for Corylaceae (mostly *Ostrya*), Fagaceae (mostly *Quercus*), Moraceae (fast all *Broussonetia*), Oleaceae (mostly *Fraxinus ornus* and *Olea*), Pinaceae (mostly *Pinus*), Platanaceae, Poaceae and Urticaceae (mostly *Parietaria*). The summer season, on the other hand, is marked by decreasing values of all the previous pollen types, and by the highest pollen shedding from Chenopodiaceae/Amaranthaceae, Asteraceae and Plantaginaceae. During the summer, Poaceae and Urticaceae pollen grains maintain relative high values. After September, only Pinaceae and Urticaceae show a relatively high pollen concentration in the air, the former because of the pollen shedding from *Cedrus*, the latter because of the long pollen season of *Parietaria*.

#### Clinical data

The mean age of the studied population is  $41 \pm 17.2$  years, with the women in majority (58.3%). 1768 persons were atopic by prick test and 676 resulted sensitized to almost one pollen extract. The most common symptom is rhinitis (40.9%), less common asthma (28.5%) while others report conjunctivitis, pharyngitis and urticaria (30.6%).

Subjects with pollenosis present frequently a skin prick test positive to Poaceae (64.9%), less common sensitisation to Oleaceae (48.8%), Betulaceae/Corylaceae (37%), *Parietaria* (35%), Cupressaceae (29%), Asteraceae (27.1%), Platanaceae (19.2%) and *Ambrosia* (14.2%). The clinical data reveal sensibility to 9 taxa (Fig. 2), 4 of which are herbaceous families and genera (Poaceae, Asteraceae, *Ambrosia*, *Parietaria*) and 5 woody families (Oleaceae, Corylaceae, Betulaceae, Cupressaceae and Platanaceae).

#### Floristic data

Over 1000 species belonging to 106 families have been recorded so far in the town of Trieste. A selection of these species was made to recognize the species locally inducing allergic diseases.

The allergenic significance of some genera or families is well known (D'Amato, 1981; D'Amato & Spiekma, 1992; D'Amato *et al.*, 1991a, 1998, 2001). Species belonging to these taxa were therefore inserted in the allergenic floristic list, where some species reported as allergenic in Ciampolini & Cresti (1981), Crimi *et al.* (1985), De Leonardis *et al.* (1985-1987) and reaching enough airborne pollen amounts were also included.

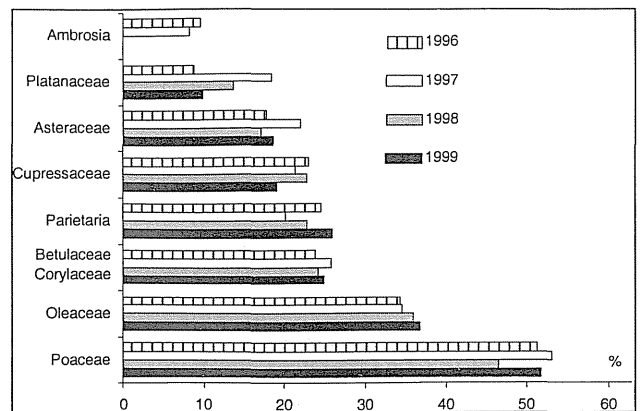


Fig. 2: Pollen sensitisation trend in the 4 considered years in Trieste.

Sl. 2: Pelodni senzibilizacijski trendi v štirih preučevanih letih v Trstu.

It is not known yet whether many other species recorded in the urban area produce pollen with allergenic properties. The identification of pollen allergens or the biochemical characterisation of the pollen has been made only for some plants of allergological interest (e.g. Shibata *et al.*, 1989; Matthiesen *et al.*, 1991; Baldo *et al.*, 1992; Mondal *et al.*, 1997; Patriarca *et al.*, 2000; Pini, 2001). Skin test reactivity to pollen extracts or clinico-immunological studies are sometimes reported for some species, which have not been known as allergenic, and not for other closely linked species (e.g. Fountain & Cornford, 1991; Ariano *et al.*, 1993; Parui *et al.*, 1998; Chakraborty *et al.*, 1999; Ravat *et al.*, 2000).

Therefore, it is very difficult to draw up a realistic list of allergenic species, as also pointed out by Driessen & Derksen (1989), Pecere & Chiesura Lorenzoni (1992), Selle *et al.* (1992), Leporatti *et al.* (2000) and Lorenzoni-Chiesura *et al.* (2000).

To summarise, on the basis of these considerations the following list contains: species with pollen allergen characterization; the species unanimously acknowledged as allergenic in the medical literature; all species belonging to genera known as allergenic in the medical literature; all species reaching high airborne pollen concentrations belonging to families known as allergenic in the medical literature.

Species not mentioned in any studies, belonging to genera or families till now unknown as allergenic or known as scarcely significant in inducing pollenosis, were not inserted. For example, the following species, though recorded in the town of Trieste and listed as allergenic in Crimi *et al.* (1985), were not included in the following list owing to their sporadic pollen occurrence in the air, too low for inducing allergic diseases: *Arum italicum*, *Heliotropium europaeum*, *Campanula rapunculus*, *Capparis spinosa*, *Cornus sanguinea*, *Ecbalium elaterium*, *Carex flacca* and *C. pendula*, *Iris ger-*

*manica*, *Laurus nobilis*, *Acacia dealbata*, *Cercis siliquastrum*, *Lotus corniculatus*, *Medicago sativa*, *Robinia pseudacacia*, *Spartium junceum*, *Trifolium pratense*, *Malva sylvestris*, *Papaver rhoeas*, *Consolida regalis*, *Ranunculus bulbosus*, *Prunus spinosa*, *Sanguisorba minor*, *Galium mollugo*, *Solanum nigrum*, *Thypha latifolia*, *Daucus carota*, *Smyrniolus olusatrum*, *Vitis vinifera*. Though listed in Ciampolini & Cresti (1981) and Crimi et al. (1985), even *Hedera helix*, whose pollen grains were abundantly found in the atmosphere of Trieste (Rizzi

Longo & Martini, 2000) and frequently occur in the air (Nilsson et al., 1977), was not included in the following list, as there is no evidence of sensitisations in literature.

In the floristic list of the local allergophytes, which are presented in systematic order, the family, the biological form, the life form and the chorological group are given for each taxon, the area of provenance only for the adventitious plants. The cultivated plants *sensu* Viegi et al. (1974) are listed in bold.

## PINACEAE

Pinaceae are reported as not-recommended plants by Lorenzoni-Chiesura et al. (2000), even if they are of low allergenic interest (Rogers, 2001). All the species found in the urban area are included in the present list due to their local airborne abundance of pollen grains.

<b><i>Abies alba</i> Mill.</b>	P scap	cult.(S-European-montane)
<b><i>Abies cephalonica</i> Loudon</b>	P scap	cult. (Greece)
<b><i>Abies nordmanniana</i> (Steven) Spach</b>	P scap	cult.(Caucasus)
<b><i>Abies pinsapo</i> Boiss.</b>	P scap	cult. (SW-Spain)
<b><i>Cedrus atlantica</i> (Endl.) Carriere</b>	P scap	cult. (Morocco)
<b><i>Cedrus deodara</i> (D. Don) Don</b>	P scap	cult. (Himalaya)
<b><i>Cedrus libani</i> A. Richard</b>	P scap	cult. (Lebanon)
<b><i>Picea abies</i> (L.) H. Karst.</b>	P scap	cult. (Eurosiberian)
<b><i>Picea orientalis</i> (L.) Link</b>	P scap	cult. (Asia minor-Caucasus)
<b><i>Picea pungens</i> (Sieb &amp; Zucc.) Carriere</b>	P scap	cult. (N-America)
<b><i>Pinus brutia</i> Ten.</b>	P scap	cult. (NE-Mediterran.-montane)
<b><i>Pinus halepensis</i> Mill.</b>	P scap	cult. (Stenomediterran.)
<i>Pinus nigra</i> J.F. Arnold ssp. <i>nigra</i>	P scap	S-Illyric
<b><i>Pinus pinaster</i> Ait.</b>	P scap	cult. (W-Stenomediterran.)
<b><i>Pinus pinea</i> L.</b>	P scap	cult. (Eurimediterran.)
<b><i>Pinus strobus</i> L.</b>	P scap	cult. (N-America)
<b><i>Pinus sylvestris</i> L.</b>	P scap	cult. (Eurosiberian)
<b><i>Pinus wallichiana</i> Jackson</b>	P scap	cult. (Central Asia)

## CUPRESSACEAE

Cupressaceae, Fagaceae and Oleaceae are the most relevant tree families in inducing allergic diseases (D'Amato, 2001). Pollen grains of Cupressaceae are responsible for winter pollenosis (Panzani et al., 1991).

<b><i>Chamaecyparis lawsoniana</i> (A. Murray bis) Parl.</b>	P scap	cult. (W-USA)
<b><i>Cupressus arizonica</i> Green</b>	P scap	cult. (N-America)
<b><i>Cupressus macrocarpa</i> Hartweg</b>	P scap	cult. (N-America)
<b><i>Cupressus sempervirens</i> L.</b>	P scap	cult. (E-Mediterran.)
<b><i>Juniperus chinensis</i> L.</b>	P scap	cult. (China, Japan)
<i>Juniperus communis</i> L. ssp. <i>communis</i>	P caesp	Circumboreal
<b><i>Juniperus virginiana</i> L.</b>	P caesp	cult. (N-America)
<b><i>Thuja occidentalis</i> L.</b>	P scap	cult. (N-America)
<b><i>Thuja orientalis</i> L.</b>	P scap	cult. (E-Asia)

## TAXACEAE

Pollen grains of *Taxus* are similar to grains of Cupressaceae, and are generally counted together in the aerobiological studies. *Taxus baccata* is reported as allergenic in Ciampolini & Cresti (1981) and Driessen & Derksen (1989).

<i>Taxus baccata</i> L.	P scap	Palaeotemperate
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## CHENOPODIACEAE

Pollen grains of Chenopodiaceae may be responsible for summer pollenosis (Bricchi *et al.*, 1997), even if of minor allergological interest (Jäger & D'Amato, 2001).

<i>Arthrocnemum fruticosum</i> (L.) Moq.	Ch succ	Eurimediterran.
<i>Atriplex hortensis</i> L.	T scap	Eurasitic
<i>Atriplex micrantha</i> Ledeb.	T caesp	Anthropochore (E-Europe)
<i>Atriplex patula</i> L.	T scap	Circumboreal
<i>Atriplex portulacoides</i> L.	Ch suffr	Circumboreal
<i>Atriplex prostrata</i> Boucher ex DC.	T scap	Circumboreal
<i>Bassia scoparia</i> (L.) A.J. Scott ssp. <i>scoparia</i>	T scap	Anthropochore (Europe/E & Centr. Asia)
<i>Beta vulgaris</i> L.	H bienn	Eurimediterran.
<i>Chenopodium album</i> L.	T scap	Cosmopolitan
<i>Chenopodium ambrosioides</i> L.	T scap	Anthropochore (Tropical America)
<i>Chenopodium botrys</i> L.	T scap	Cosmopolitan
<i>Chenopodium hybridum</i> L.	T scap	Circumboreal
<i>Chenopodium murale</i> L.	T scap	Cosmopolitan
<i>Chenopodium polyspermum</i> L.	T scap	Palaeotemperate
<i>Salicornia patula</i> Duval-Jouve	T scap	European
<i>Salsola soda</i> L.	T scap	Palaeotemperate
<i>Suaeda maritima</i> (L.) Dumort ssp. <i>maritima</i>	T scap	Cosmopolitan

## AMARANTHACEAE

The pollen grains of Amaranthaceae and Chenopodiaceae are very much alike. In the aerobiological studies they are counted together as Cheno-Amaranthaceae. In some cases they are responsible for seasonal allergic diseases (Lombardero *et al.*, 1991).

<i>Amaranthus albus</i> L.	T scap	Anthropochore (N-America)
<i>Amaranthus blitoides</i> S. Watson	T scap	Anthropochore (N-America)
<i>Amaranthus blitum</i> L. ssp. <i>blitum</i>	T scap	Eurimediterran.
<i>Amaranthus bouchonii</i> Thell.	T scap	Anthropochore (unkn.)
<i>Amaranthus cruentus</i> L.	T scap	Anthropochore (America)
<i>Amaranthus deflexus</i> L.	T scap	Anthropochore (S-America)
<i>Amaranthus graecizans</i> L.	T scap	Anthropochore (Subcosmopolitan)
<i>Amaranthus hybridus</i> L.	T scap	Anthropochore (N & SW-America)
<i>Amaranthus retroflexus</i> L. ssp. <i>retroflexus</i>	T scap	Anthropochore (N-America)

## POLYGONACEAE

*Rumex*, put by D'Amato (2001) in the group of allergenic weeds, releases in the air pollen of minor allergological interest (Jäger & D'Amato, 2001). *Rumex* shows a not well-defined clinical relevance (Frank *et al.*, 1991).

<i>Rumex acetosa</i> L. ssp. <i>acetosa</i>	H scap	Circumboreal
<i>Rumex conglomeratus</i> Murray	H scap	Eurasitic
<i>Rumex crispus</i> L. ssp. <i>crispus</i>	H scap	Cosmopolitan
<i>Rumex kernerii</i> Borbás	H scap	Anthropochore (SE-European)
<i>Rumex obtusifolius</i> L. ssp. <i>obtusifolius</i>	H scap	European
<i>Rumex pulcher</i> L. ssp. <i>pulcher</i>	H scap	Eurimediterran.

## PLATANACEAE

The pollen of *Platanus* is allergenic, but Platanaceae are of reduced allergenic importance in Europe (Jäger & D'Amato, 2001).

<i>Platanus × hispanica</i> Mill. ex Münchh.	P scap	Eurimediterran.
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## FAGACEAE

Cross-reactivity is frequent among Fagales (D'Amato, 2001). When airborne pollen grains are abundant, Fagaceae could be responsible for allergic manifestations (Ickovic & Thibaudon, 1991).

<i>Castanea sativa</i> Mill.	P scap	SE-European
<i>Quercus cerris</i> L.	P scap	Eurimediterran.
<i>Quercus ilex</i> L. ssp. <i>ilex</i>	P scap	Stenomediterran.
<i>Quercus petraea</i> Liebl.	P scap	European
<i>Quercus pubescens</i> Willd.	P caesp	Pontic

## BETULACEAE

Pollen from Betulaceae, particularly from *Betula*, is a significant contributor to the incidence of pollenosis in northern and central Europe (D'Amato, 1991; Vik *et al.*, 1991). *Alnus* shows a high degree of cross-reactivity with *Betula* pollen allergens (Spieksma & Frenguelli, 1991).

<i>Alnus glutinosa</i> (L.) Gaertn.	P scap	Palaeotemperate
<b><i>Betula pendula</i> Roth</b>	<b>P scap</b>	<b>cult. (Eurosiberian)</b>

## CORYLACEAE

Cross-reactivity is frequent among Fagales, *i.e.* between *Corylus* of reduced allergenic importance (Jäger & D'Amato, 2001) and *Betula* (D'Amato, 2001). *Ostrya carpinifolia* has recently shown an increased allergenic interest (Voltolini, 2001).

<i>Carpinus betulus</i> L.	P scap	European
<i>Carpinus orientalis</i> Mill.	P caesp	Pontic
<i>Corylus avellana</i> L.	P caesp	European
<b><i>Corylus colurna</i> L.</b>	<b>P caesp</b>	<b>cult. (Balkan Peninsula)</b>
<b><i>Corylus maxima</i> Miller</b>	<b>P caesp</b>	<b>cult. (Pontic)</b>
<i>Ostrya carpinifolia</i> Scop.	P caesp	Mediterran.-Pontic

## ULMACEAE

*Ulmus* is also a plant of allergological interest (Matthiesen *et al.*, 1991). A low skin test reactivity to pollen of *Celtis* is reported in Rogers (2001).

<i>Celtis australis</i> L.	P scap	Eurimediterran.
<i>Ulmus laevis</i> Pall.	P caesp	Anthropochore (Central Europe)
<i>Ulmus minor</i> Mill. ssp. <i>minor</i>	P caesp	European
<b><i>Ulmus pumila</i> L.</b>	<b>P scap</b>	<b>Anthropochore (E-Asia)</b>

## MORACEAE

*Morus* is an important plant in inducing pollen allergy (Matthiesen *et al.*, 1991). *Broussonetia papyrifera*, a doubtful allergenic species, was put on the present list due to the high amount of airborne pollen grains detected in the air of the town.

<i>Broussonetia papyrifera</i> (L.) Vent.	P caesp	Anthropochore (E-Asia)
<i>Morus alba</i> L.	P scap	Anthropochore (E-Asia)

## CANNABACEAE

Pollen of *Humulus* is reported as allergenic in Ciampolini & Cresti (1981).

<i>Humulus lupulus</i> L.	P lian	European
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## URTICACEAE

*Parietaria* is the most relevant allergenic genus in the Mediterranean region, while *Urtica* shows a small clinical relevance (D'Amato *et al.*, 1991b).

<i>Parietaria judaica</i> L.	H scap	Eurimediterran.
<i>Parietaria officinalis</i> L.	H scap	European
<i>Urtica dioica</i> L. ssp. <i>dioica</i>	H scap	Cosmopolitan
<i>Urtica urens</i> L.	T scap	Cosmopolitan

## JUGLANDACEAE

A moderate skin test reactivity to pollen of *Juglans* is reported in Rogers (2001).

<i>Juglans regia</i> L.	P scap	Anthropochore (SW-Asia/E-Mediterran.)
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## ACERACEAE

*Acer* is one of the plants of allergological interest (Matthiesen *et al.*, 1991).

<i>Acer campestre</i> L.	P scap	European
<i>Acer monspessulanum</i> L.		
ssp. <i>monspessulanum</i>	P scap	Eurimediterran.
<i>Acer negundo</i> L.	P scap	Anthropochore (N-America)
<i>Acer platanoides</i> L.	P scap	European
<i>Acer pseudoplatanus</i> L.	P scap	European

## HIPPOCASTANACEAE

*Aesculus* is reported as a not-recommended tree in Lorenzoni-Chiesura *et al.* (2000). A very low skin test reactivity to pollen of *Aesculus* is reported in Rogers (2001).

<i>Aesculus hippocastanum</i> L.	P scap	Anthropochore (SE-European)
<b><i>Aesculus</i> × <i>carnea</i> Hayne</b>	<b>P scap</b>	<b>cult. (unkn.)</b>

## EUPHORBIACEAE

*Mercurialis* releases pollen of minor allergological interest (Jäger & D'Amato, 2001).

<i>Mercurialis annua</i> L. ssp. <i>annua</i>	T scap	Palaeotemperate
<i>Mercurialis ovata</i> Sternb. & Hoppe	G rhiz	Pontic
<i>Mercurialis perennis</i> L.	G rhiz	European

## BRASSICACEAE

*Brassica napus* is a weed of minor allergological interest (Jäger & D'Amato, 2001). *Capsella bursa-pastoris* and *Erysimum cheiri*, collected in the town, are listed among allergenic species in Crimi *et al.* (1985), but were not inserted in the present list owing to their small airborne pollen amount and scarce clinical data.

<i>Brassica napus</i> L. ssp. <i>napus</i>	T scap	Anthropochore (unkn.)
<i>Brassica oleracea</i> L.	Ch suffr	Mediterr.-Atlantic
<i>Brassica rapa</i> L.	T scap	Eurimediterran.

## SALICACEAE

*Populus* is a tree of allergological interest (Matthiesen *et al.*, 1991). *Salix alba* is noted as allergenic in Driessen & Derksen (1989).

<i>Populus alba</i> L.	P scap	Palaeotemperate
<i>Populus nigra</i> L. ssp. <i>nigra</i>	P scap	Palaeotemperate
<i>Populus tremula</i> L.	P scap	Eurosiberian
<i>Populus</i> × <i>canescens</i> (Aiton) Sm.	P scap	SE-European
<i>Salix alba</i> L. var. <i>alba</i>	P scap	Palaeotemperate
<b><i>Salix babylonica</i> L.</b>	<b>P scap</b>	<b>cult. (E-Asia)</b>
<i>Salix caprea</i> L.	P caesp	Eurasiatic
<i>Salix cinerea</i> L. ssp. <i>cinerea</i>	P caesp	Palaeotemperate
<i>Salix daphnoides</i> Vill.	P caesp	Eurasiatic

*Salix purpurea* L. ssp. *purpurea*  
***Salix* × *sepulcralis* L.**

P caesp  
P scap

Eurasiatic  
cult. (unkn.)

# TILIACEAE

*Tilia* seems responsible for allergic manifestations (Ciampolini & Cresti, 1981; Mur et al., 2001).

*Tilia cordata* Mill.  
*Tilia platyphyllos* Scop. ssp. *platyphyllos*

P scap  
P scap

European  
European

# OLEACEAE

There is a high degree of cross-reactivity among *Olea* and other genera of Oleaceae. Pollen from *Olea* is one of the most relevant allergenic pollens in Mediterranean Europe (Macchia et al., 1991).

***Forsythia* × *intermedia* Zab.**  
***Forsythia viridissima* Lindl.**

P caesp  
P caesp

cult. (E-Asia)  
cult. (E-Asia)

*Fraxinus excelsior* L. ssp. *excelsior*  
*Fraxinus ornus* L. ssp. *ornus*

P scap  
P scap

European  
Mediterr.-Pontic

***Jasminum nudiflorum* Lindl.**

P caesp

cult.

*Ligustrum lucidum* Ait.

P scap

Anthropochore (E-Asia)

*Ligustrum vulgare* L.

NP

European

***Olea europaea* L.**

P caesp

cult. (Stenomediterran.)

*Syringa vulgaris* L.

P caesp

Mediterr.-Montane

# CAPRIFOLIACEAE

*Sambucus nigra* is reported as allergenic in Driessen & Derksen (1989), the same as *S. ebulus* in Ciampolini & Cresti (1981).

*Sambucus ebulus* L.  
*Sambucus nigra* L.

H scap  
P caesp

Eurimediterran.  
European

# ASTERACEAE

A great number of species recorded in the town of Trieste belongs to Asteraceae, but only the wind pollinated species belonging to *Artemisia* and *Ambrosia* are relevant in inducing allergic diseases (Jäger, 1991; Jäger & D'Amato, 2001). Pollen grains from a small number of entomophilous plants belonging to Asteraceae, such as *Solidago*, *Taraxacum* and *Helianthus*, may be incidentally released into the air, but are obviously of minor allergenic significance (Spijksma & Von Wahl, 1991). *Xanthium* and *Chrysanthemum* (in the past including *Leucanthemum* and *Tanacetum*) are listed among the taxa of allergological interest (Matthiesen et al., 1991) and were therefore included in the present list. Other species recorded in the urban area release into the air a little amount of pollen grains, too low for inducing allergic diseases. They were therefore not inserted in this list, the same as, for instance, *Aster squamatus*, *Centaurea calcitrapa* and *Inula viscosa* listed in Crimi et al. (1985), *Tussilago farfara* mentioned by Ciampolini & Cresti (1981), *Bellis perennis* and *Matricaria chamomilla* reported in Leporatti et al. (2000).

*Ambrosia artemisiifolia* L.  
*Artemisia absinthium* L.  
*Artemisia alba* Turra ssp. *lobelii* (All.) Gams  
*Artemisia annua* L.  
*Artemisia caerulea* L. ssp. *caerulea*  
*Artemisia verlotorum* Lamotte  
*Artemisia vulgaris* L. ssp. *vulgaris*  
*Chrysanthemum segetum* L.  
*Helianthus annuus* L.  
*Helianthus tuberosus* L.  
*Leucanthemum ircutianum* (Turcz.) DC.  
*Leucanthemum platylepis* Borbás  
*Solidago gigantea* Aiton  
*Solidago virgaurea* L. ssp. *virgaurea*

T scap  
Ch suffr  
Ch suffr  
T scap  
Ch suffr  
H scap  
H scap  
T scap  
T scap  
G bulb  
H scap  
H scap  
H scap  
H scap

Anthropochore (N-America)  
Eurimediterran.  
Eurimediterran.  
Eurasitic  
Eurimediterran.  
Eurasitic  
Circumboreal  
Mediterr.-Atlantic  
Anthropochore (N-America)  
Anthropochore (N-America)  
Eurimediterran.  
S-Illyric  
Anthropochore (N-America)  
Circumboreal



<i>Tanacetum corymbosum</i> (L.) Sch. Bip.		
ssp. <i>corymbosum</i>	H scap	Eurimediterran.
<i>Tanacetum parthenium</i> (L.) Sch. Bip.	H scap	Anthropochore (SE-Europe/SW-Asia)
<i>Tanacetum vulgare</i> L.	H scap	Eurasianic
<i>Taraxacum laevigatum</i> (Willd.) DC.	H ros	Palaeotemperate
<i>Taraxacum officinale</i> aggr.	H ros	Circumboreal
<i>Xanthium italicum</i> Moretti	T scap	Eurimediterran.

## PLANTAGINACEAE

Pollen from Plantaginaceae is of minor allergological interest (Jäger & D'Amato, 2001) and may contribute to pollenosis only under exceptional conditions (Watson & Constable, 1991).

<i>Plantago argentea</i> Chaix ssp. <i>liburnica</i> Ravnik	H ros	Pontic
<i>Plantago coronopus</i> L. ssp. <i>coronopus</i>	T scap	Eurimediterran.
<i>Plantago holosteum</i> Scop.	H ros	Pontic
<i>Plantago lanceolata</i> L.	H ros	Eurasianic
<i>Plantago major</i> L.	H ros	Eurasianic
<i>Plantago media</i> L. ssp. <i>media</i>	H ros	Eurasianic

## POACEAE

Pollen from Poaceae is the major cause of pollenosis in the world (D'Amato, 2001). All species recorded in the town were put on the list due to their known cross-reactivity (Weeke & Spieksma, 1991), the widespread lasting pollen shedding and the high frequency of sensitisations to Poaceae recorded in the locally studied population.

<i>Aegilops cylindrica</i> Host	T scap	Pontic
<i>Aegilops geniculata</i> Roth ssp. <i>geniculata</i>	T scap	Stenomediterran.
<i>Agrostis capillaris</i> L. ssp. <i>capillaris</i>	H caesp	Circumboreal
<i>Agrostis stolonifera</i> L.	H rept	Circumboreal
<i>Aira elegantissima</i> Schur	T scap	Eurimediterran.
<i>Alopecurus myosuroides</i> Huds.	T scap	Palaeotemperate
<i>Anisantha diandra</i> (Roth) Tutin		
ex Tzvelev ssp. <i>diandra</i>	T scap	Eurimediterran.
<i>Anisantha madritensis</i> (L.) Nevski ssp. <i>madritensis</i>	T scap	Eurimediterran.
<i>Anisantha sterilis</i> (L.) Nevski	T scap	Eurimediterran.
<i>Anisantha tectorum</i> (L.) Nevski	T scap	Palaeotemperate
<i>Anthoxanthum odoratum</i> L.		
ssp. <i>odoratum</i>	H caesp	Eurasianic
<i>Apera spica-venti</i> (L.) P. Beauv.	T scap	Eurosiberian
<i>Arrhenatherum elatius</i> (L.) P. Beauv.		
ex J. Presl & C. Presl ssp. <i>elatius</i>	H caesp	Palaeotemperate
<i>Arundo donax</i> L.	G rhiz	Anthropochore (Asia)
<i>Avena barbata</i> Pott. ex Link ssp. <i>barbata</i>	T scap	Eurimediterran.
<i>Avena fatua</i> L. ssp. <i>fatua</i>	T scap	Eurasianic
<i>Avena sativa</i> L.	T scap	Anthropochore (E-Asia)
<i>Avena sterilis</i> L. ssp. <i>sterilis</i>	T scap	Eurimediterran.
<i>Bothriochloa ischaemum</i> (L.) Keng	H caesp	Mediterr.-Pontic
<i>Brachypodium rupestre</i> (Host) Roem.		
& Schult. ssp. <i>rupestre</i>	H caesp	European
<i>Brachypodium sylvaticum</i> (Huds.)		
P. Beauv. ssp. <i>sylvaticum</i>	H caesp	Palaeotemperate
<i>Briza media</i> L. ssp. <i>media</i>	H caesp	Eurosiberian
<i>Bromopsis condensata</i> (Hack.) Holub		
ssp. <i>microtricha</i> (Borbás) Jogan & Bačič	H caesp	Illyric-S-Alpine
<i>Bromopsis erecta</i> (Huds.) Fourr.	H caesp	Palaeotemperate
<i>Bromopsis inermis</i> (Leyss.) Holub	H caesp	Eurasianic
<i>Bromus commutatus</i> Schrad.	T scap	European

<i>Bromus hordeaceus</i> L.	T scap	Cosmopolitan
<i>Bromus japonicus</i> Thunb. ssp. <i>japonicus</i>	T scap	Palaeotemperate
<i>Calamagrostis arundinacea</i> (L.) Roth		
ssp. <i>arundinacea</i>	H caesp	Eurasiatic
<i>Calamagrostis epigejos</i> (L.) Roth		
ssp. <i>epigejos</i>	H caesp	Eurosiberian
<i>Catapodium marimum</i> (L.) C.E. Hubb.	T scap	Mediterr.-Atlantic
<i>Catapodium rigidum</i> (L.) C.E. Hubb.		
ex Dony ssp. <i>rigidum</i>	T scap	Eurimediterran.
<i>Cenchrus longispinus</i> (Hack.) Fernald	T scap	Anthropochore (America)
<i>Ceratochloa cathartica</i> (Vahl) Herter	H caesp	Anthropochore (S-America)
<i>Chrysopogon gryllus</i> (L.) Trin.	H caesp	Eurosiberian
<i>Cleistogenes serotina</i> (L.) Keng	H caesp	Eurimediterran.
<i>Cynodon dactylon</i> (L.) Pers.	G rhiz	Cosmopolitan
<i>Cynosurus cristatus</i> L.	H caesp	European
<i>Cynosurus echinatus</i> L.	T scap	Eurimediterran.
<i>Dactylis glomerata</i> L. ssp. <i>glomerata</i>	H caesp	Palaeotemperate
<i>Danthonia decumbens</i> (L.) DC. ssp. <i>decumbens</i>	H caesp	European
<i>Dasypyrum villosum</i> (L.) P. Candargy	T scap	Eurimediterran.
<i>Deschampsia flexuosa</i> (L.) Trin. ssp. <i>flexuosa</i>	H caesp	Cosmopolitan
<i>Digitaria ischaemum</i> (Schreb. ex Schweigg.)		
Schreb. ex Muhl.	T scap	Cosmopolitan
<i>Digitaria sanguinalis</i> (L.) Scop. ssp. <i>sanguinalis</i>	T scap	Cosmopolitan
<i>Echinochloa crus-galli</i> (L.) P. Beauv.		
ssp. <i>crus-galli</i>	T scap	Cosmopolitan
<i>Eleusine indica</i> (L.) Gaertn. ssp. <i>indica</i>	T scap	Cosmopolitan
<i>Eleusine tristachya</i> (Lam.) Lam.	T scap	Anthropochore (S-America)
<i>Elytrigia atherica</i> (Link) Kerguélen		
ex Carreras Martínez	G rhiz	Eurimediterran.
<i>Elytrigia intermedia</i> (Host) Nevski ssp. <i>intermedia</i>	G rhiz	Eurosiberian
<i>Elytrigia intermedia</i> (Host) Nevski		
ssp. <i>barbulata</i> (Schur) Á. Löve	G rhiz	Eurosiberian
<i>Elytrigia repens</i> (L.) Desv. ex Nevski	G rhiz	Circumboreal
<i>Eragrostis cilianensis</i> (All.) Vignolo ex Janch.	T scap	Cosmopolitan
<i>Eragrostis minor</i> Host	T scap	Cosmopolitan
<i>Eragrostis pectinacea</i> (Michx.) Nees	T scap	Anthropochore (N-America)
<i>Eragrostis pilosa</i> (L.) P. Beauv.	T scap	Cosmopolitan
<i>Eragrostis virescens</i> J. Presl	T scap	Anthropochore (S-America)
<i>Festuca arundinacea</i> Schreb. ssp. <i>arundinacea</i>	H caesp	Palaeotemperate
<i>Festuca heterophylla</i> Lam. ssp. <i>heterophylla</i>	H caesp	European
<i>Festuca pratensis</i> Huds. ssp. <i>pratensis</i>	H caesp	Eurasiatic
<i>Festuca rubra</i> L. ssp. <i>rubra</i>	H caesp	Circumboreal
<i>Festuca rupicola</i> Heuf. ssp. <i>rupicola</i>	H caesp	SE-European
<i>Festuca valesiaca</i> Schleich. ex Gaudin		
ssp. <i>valesiaca</i>	H caesp	European
<i>Holcus lanatus</i> L.	H caesp	Circumboreal
<i>Hordeum murinum</i> L.		
ssp. <i>leporinum</i> (Link) Arcang.	T scap	Eurimediterran.
<i>Hordeum murinum</i> L. ssp. <i>murinum</i>	T scap	Circumboreal
<i>Koeleria lobata</i> (M. Bieb.) Roem. & Schult.	H caesp	Medit.-Mont.
<i>Koeleria macrantha</i> (Ledeb.) Schult	H caesp	Circumboreal
<i>Koeleria pyramidata</i> (Lam.) P. Beauv. ssp. <i>pyramidata</i>	H caesp	European
<i>Lagurus ovatus</i> L. ssp. <i>ovatus</i>	T scap	Eurimediterran.
<i>Lolium multiflorum</i> Lam.	T scap	Eurimediterran.
<i>Lolium perenne</i> L.	H caesp	Eurasiatic
<i>Melica ciliata</i> L.	H caesp	Eurimediterran.

<i>Melica uniflora</i> Retz.	H caesp	Palaeotemperate
<i>Molinia caerulea</i> (L.) Moench		
ssp. <i>arundinacea</i> (Schränk) H.K.G. Paul	H caesp	European
<i>Muhlenbergia vaginiflora</i> (Torr. ex A.. Gray) Jogan	T caesp	Anthropochore (N-America)
<i>Panicum capillare</i> L.	T scap	Anthropochore (N-America)
<i>Panicum dichotomiflorum</i> Michx.	T scap	Anthropochore (N & C-America)
<i>Panicum miliaceum</i> L. ssp. <i>miliaceum</i>	T scap	Anthropochore (Asia)
<i>Parapholis incurva</i> (L.) C.E. Hubb.	T scap	Medit.-Atlan.
<i>Paspalum dilatatum</i> Poir.	H caesp	Anthropochore (S-America)
<i>Paspalum distichum</i> L.	G rhiz	Anthropochore (Neotropical)
<i>Phalaris arundinacea</i> L. ssp. <i>arundinacea</i>	He	Circumboreal
<i>Phalaris canariensis</i> L.	T scap	Anthropochore (W-Mediterran.)
<i>Phalaris paradoxa</i> L.	T scap	Stenomediterran.
<i>Phleum bertolonii</i> DC.	H caesp	Eurimediterran.
<i>Phleum pratense</i> L.	H caesp	European
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	He	Cosmopolitan
<i>Piptatherum miliaceum</i> (L.) Coss. ssp. <i>miliaceum</i>	H caesp	Stenomediterran.
<i>Poa angustifolia</i> L.	H caesp	Cosmopolitan
<i>Poa annua</i> L. ssp. <i>annua</i>	T caesp	Cosmopolitan
<i>Poa bulbosa</i> L. ssp. <i>bulbosa</i>	H caesp	Palaeotemperate
<i>Poa compressa</i> L.	H caesp	Circumboreal
<i>Poa nemoralis</i> L. ssp. <i>nemoralis</i>	H caesp	Circumboreal
<i>Poa pratensis</i> L.	H caesp	Circumboreal
<i>Poa trivialis</i> L. ssp. <i>sylvicola</i> (Guss.) H. Lindb.	H caesp	Eurimediterran.
<i>Poa trivialis</i> L. ssp. <i>trivialis</i>	H caesp	Eurasianic
<i>Polypogon monspeliensis</i> (L.) Desf.	T scap	Subtropical
<i>Polypogon viridis</i> (Gouan) Breistr.	H caesp	Eurimediterran.
<i>Puccinellia festuciformis</i> (Host) Parl. ssp. <i>festuciformis</i>	H caesp	Stenomediterran.
<i>Rostraria cristata</i> (L.) Tzvelev	T caesp	Palaeotemperate
<i>Sesleria autumnalis</i> (Scop.) F.W. Schultz	H caesp	SE-European
<i>Setaria italica</i> (L.) P. Beauv. ssp. <i>italica</i>	T scap	Cosmopolitan
<i>Setaria pumila</i> (Poir.) Roem. & Schult.	T scap	Cosmopolitan
<i>Setaria verticillata</i> (L.) P. Beauv.	T scap	Cosmopolitan
<i>Setaria verticilliformis</i> Dumort.	T scap	Cosmopolitan
<i>Setaria viridis</i> (L.) P. Beauv.	T scap	Cosmopolitan
<i>Sorghum halepense</i> (L.) Pers.	G rhiz	Cosmopolitan
<i>Sporobolus indicus</i> (L.) R. Br.	H caesp	Anthropochore (N-America)
<i>Sporobolus neglectus</i> Nash	T caesp	Anthropochore (N-America)
<i>Stipa eriocalis</i> Borbás		
ssp. <i>austriaca</i> (Beck) Martinovsky	H caesp	Eurimediterran.
<i>Trisetum flavescens</i> (L.) P. Beauv.		
ssp. <i>flavescens</i>	H caesp	Eurasianic
<i>Triticum aestivum</i> L.	T scap	Anthropochore (SW-Asia)
<i>Vulpia ciliata</i> Dumort.	T caesp	Eurimediterran.
<i>Vulpia myuros</i> (L.) C.C. Gmel. ssp. <i>myuros</i>	T caesp	Cosmopolitan

## DISCUSSION

Among the over 1000 wild and cultivated species found in the urban area during the field work, in order to draw up the allergenic flora of Trieste, were selected those ones locally inducing allergic diseases. The selection was carried out using the data resulting from the local aerobiological and epidemiological monitoring and on the basis of the medical literature. About a quarter of the recorded species were regarded as allergenic. In the

following discussion, it does not consider the cultivated species.

The family composition of the allergenic wild flora (Tab. 1) shows that the core of the group is represented by Poaceae (50.4%), which account for about a half of the total number of taxa, followed by Asteraceae (8.8%) and Chenopodiaceae (7%). Amaranthaceae, Salicaceae, Plantaginaceae, Polygonaceae and others have a clearly subordinate role.

Tab. 1: Family composition of the allergenic flora of Trieste.

Tab. 1: Sestava tržaške alergene flore po družinah.

Family	%	Family	%
Poaceae	50.4	Cruciferae	1.3
Asteraceae	8.8	Euphorbiaceae	1.3
Chenopodiaceae	7.0	Caprifoliaceae	0.9
Amaranthaceae	3.9	Moraceae	0.9
Salicaceae	3.9	Tiliaceae	0.9
Plantaginaceae	2.6	Betulaceae	0.4
Polygonaceae	2.6	Cannabaceae	0.4
Aceraceae	2.2	Cupressaceae	0.4
Fagaceae	2.2	Hippocastanaceae	0.4
Oleaceae	2.2	Juglandaceae	0.4
Corylaceae	1.8	Pinaceae	0.4
Ulmaceae	1.8	Platanaceae	0.4
Urticaceae	1.8	Taxaceae	0.4

Tab. 2: Life form and growth form spectra of the allergenic flora of Trieste.

Tab. 2: Spekter življenjskih in rastnih oblik tržaške alergene flore.

Life form	Growth form	%
<b>Therophytes</b>		<b>37.7</b>
	scapose	34.6
	caespitose	3.1
<b>Hemicryptophytes</b>		<b>34.2</b>
	caespitose	21.9
	scapose	8.3
	rosulate	3.1
	biennial	0.4
	reptant	0.4
<b>Phanerophytes</b>		<b>19.7</b>
	scapose	12.7
	caespitose	6.1
	nanophanerophytic	0.4
	lianas	0.4
<b>Geophytes</b>		<b>4.8</b>
	rhizomatous	4.4
	bulbous	0.4
<b>Chamaephytes</b>		<b>2.6</b>
	suffrutescent	2.2
	succulent	0.4
<b>Helophytes</b>		<b>0.9</b>

The life form spectrum of the allergenic wild species (Tab. 2) is dominated by therophytes and hemicryptophytes (together more than 70% of the total); the therophytes are dominated by the scapose (34.6%), and the hemicryptophytes by the caespitose (21.9%). The presence of parks and gardens, especially on the town's out-

skirts, is well outlined by the high percentage of phanerophytes scapose (12.7%) and caespitose (6.1%), as *Pinus nigra* ssp. *nigra*, *Quercus pubescens*, *Carpinus orientalis*, *Corylus avellana*, *Ostrya carpinifolia*, *Ulmus minor*, *Broussonetia papyrifera*, *Acer campestre*, *Fraxinus ornus*, *Sambucus nigra* and others.

The chorological spectrum (Tab. 3) is highlighted by the adventitious element (18.9%) and particularly by the N-American neophytes (Tab. 4), which constitute more than a third of the total percentage (34.8%) of the anthropochores. Other macrothermic chorotypes (*sensu* Poldini & Martini, 1995) as Eurimediterranean (16.7%) are also well represented, the same as some mesothermic geoelements as European (11.4%) or palaeotemperate (9.2%).

Tab. 3: Chorological spectrum of the allergenic flora of Trieste.

Tab. 3: Kronološki spekter tržaške alergene flore.

Chorological group	%
Adventitious	18.9
Eurimediterranean	16.7
Cosmopolitan	11.8
European	11.4
Palaeotemperate	9.2
Circumboreal	8.3
Eurasian	8.3
Eurosiberian	3.1
Pontic	2.6
Stenomediterranean	2.2
Mediterr.-Atlantic	1.8
SE-European	1.8
Mediterr.-Pontic	1.3
Mediterr.-Montane	0.9
S-Illyric	0.9
Illyric-S-Alpine	0.4
Neotropical	0.4

Tab. 4: Origin of the anthropochores of the allergenic flora of Trieste.

Tab. 4: Izvor antropohornih elementov v tržaški alergeni flori.

Origin	%
<b>America</b>	<b>53.5</b>
North & Central Am.	34.8
South Am.	13.9
North & South Am.	4.7
<b>Asia</b>	<b>18.6</b>
<b>Europe</b>	<b>14.0</b>
<b>Mediterranean basin</b>	<b>6.9</b>
<b>Neotropical</b>	<b>2.3</b>
<b>unknown</b>	<b>4.7</b>

Regarding the origin of the allergophytic anthropochores, Table 4 shows that the American species (53.5%) distinctly prevail over the others, particularly Asiatic (18.6%) and European neophytes (14%).

The results of this research have shown that 264 allergenic taxa (species, subspecies and hybrids), belonging to 26 allergenic families, are found in the urban flora of Trieste. Of these, 35 are cultivated species and hybrids (e.g. *Salix x sepulcralis* or *Aesculus x carnea*) not growing wild and not considered in the previous discussion, while 229 are indigenous or adventitious taxa. Most of these are hemerophytic species as defined by

Ahti & Hamet Ahti (1971). There are also several species belonging to the semi-natural vegetation, for instance *Quercetalia pubescenti-petraeae*, *Festuco-Brometea* or *Molinio-Arrhenatheretea*, growing in some natural parks inside the town, as Villa Giulia and Bosco Farneto, or on the town's outskirts.

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#### POVZETEK

*Med preučevanjem alergene flore v Trstu so avtorji članka opravljali aerobiološki monitoring, klinične analize in terensko delo hkrati. Z uporabo podatkov iz medicinske in aerobiološke literature in tudi na osnovi podatkov, pridobljenih z lokalnim aerobiološkim in epidemiološkim monitoringom, so napravili izbor več kot tisoč vrst, zabeleženih v mestnem urbanem okolju, da bi identificirali vrste, ki povzročajo alergijske bolezni. Ugotovljeno je bilo, da v Trstu raste 264 alergofitov, pripadajočim 26 alergenim družinam.*

**Ključne besede:** aerobiološki monitoring, alergena flora, klinični podatki, pelodni koledar, Trst, Italija

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THE EFFECTS OF UV-B RADIATION ON AQUATIC AND TERRESTRIAL  
PRIMARY PRODUCERS

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## ABSTRACT

*The effect of enhanced UV-B radiation on aquatic and terrestrial primary producers is reviewed, based on the data from literature and those derived from experiments performed under UV-B doses corresponding to 17% ozone depletion. The changes of the following parameters, i.e. total contents of UV-B absorbing compounds and photosynthetic pigments, terminal electron transport system (ETS) activity and photochemical efficiency of photosystem II, were compared in different species. In some species, UV-B induced synthesis of UV-B absorbing compounds, while the others did not respond to enhanced UV-B or synthesised saturated amounts of these substances, with no respect to UV-B level. It was established that the production of UV-B absorbing compounds demanded additional energy in *Scenedesmus quadricauda*, *Selenastrum capricornutum* and *Ceratophyllum demersum*, since it was correlated to ETS activity. Generally, no effect on potential and actual photochemical efficiencies of photosystem II was observed.*

**Key words:** UV-B radiation, primary producers, UV-B absorbing compounds, photochemical efficiency of PS II, terminal electron transport activity

## EFFETTI DELLA RADIAZIONE UV-B SU PRODUTTORI PRIMARI ACQUATICI E TERRESTRI

## SINTESI

*L'articolo presenta una revisione degli effetti di un'aumentata radiazione UV-B su produttori primari acquatici e terrestri, basata su dati di letteratura e su risultati di esperimenti condotti con dosi di UV-B corrispondenti ad un impoverimento in ozono pari al 17%. Le variazioni nei seguenti parametri sono state confrontate per diverse specie: contenuto totale di composti e pigmenti fotosintetici assorbenti raggi UV, attività terminale di trasporto elettroni (ETS) ed efficienza fotochimica del fotosistema II. In alcune specie la radiazione UV-B ha indotto la sintesi di composti assorbenti UV-B, mentre altre specie non hanno manifestato risposta all'aumentata radiazione UV-B o hanno sintetizzato quantità sature di tali sostanze, a prescindere dal livello di UV-B. In *Scenedesmus quadricauda*, *Selenastrum capricornutum* e *Ceratophyllum demersum*, la produzione di composti assorbenti UV-B ha richiesto tassi più elevati di energia, in quanto correlata all'attività ETS. Gli autori non hanno osservato effetti sull'efficienza fotochimica potenziale o effettiva del fotosistema II.*

**Parole chiave:** radiazione UV-B, produttori primari, composti assorbenti UV-B, efficienza fotochimica di PS II, attività terminale di trasporto elettroni.

## INTRODUCTION

The intensive UV research during recent years is the result of our concern regarding the thinning of ozone layer in the stratosphere and consequently increasing ultraviolet (UV) radiation levels that may influence terrestrial as well as aquatic ecosystems (Rozema *et al.*, 1997; Häder *et al.*, 1998; Trošt & Gaberščik, 2001; Gaberščik *et al.*, 2001; Gaberščik *et al.*, 2002a, b; Germ *et al.*, 2002a, b; Rozema *et al.*, 2002). UV-B radiation causes damage to nucleic acids by absorption of UV-B photons by DNA and formation of cyclobutane dimers as well as by formation of free radicals. Membrane damages occur as a consequence of photoabsorption, peroxidation and changes in the membrane lipid composition. UV-B radiation affects photosynthesis by damaging photosystem II (Björn, 1999; Xiong, 2001), disruption of thylakoid membrane, reduction in chlorophyll content, disturbance of membrane permeability and damaging RuBP carboxylase (ribulose-1.5-bisphosphate). It has been established that the activity of respiratory electron transport system (ETS) is enhanced by UV-B (Ferreira *et al.*, 1997; Gaberščik *et al.*, 2002a). UV-B radiation also affected the activity of phytohormones by influencing the synthesis or by inactivation. Plant morphogenetic responses to enhanced solar UV-B radiation are decreases in height, leaf length, leaf area, increases in leaf thickness, altered leaf angle, plant architecture, canopy structure, altered emergence, phenology, senescence, and seed production (Newsham *et al.*, 1996; Rozema *et al.*, 1997; Gaberščik *et al.*, 2002b). Enhanced UV-B results in the disturbance of motility and orientation of phytoplankton (Cullen *et al.*, 1992) decrease cell wall thickness, inhibited enzyme activity and metabolism of nitrogen (Häder, 1996; Nielsen, 1996).

Protection against UV-B radiation is of primary importance for photosynthetic organisms, which depend on solar radiation as the primary source of energy. Organisms have evolved different strategies and mechanisms to cope with UV-B stress. The general response found in the majority of primary producers is enhanced production of UV-absorbing compounds, which provide a protection screen filtering out harmful UV radiation (Sommaruga, 2001; Xiong, 2001; Gaberščik *et al.*, 2002b, Germ *et al.*, 2002a). The concentration and type of these compounds generally depends on the group of organisms and the level of UV-B radiation (Holm-Hansen *et al.*, 1993; Hannach & Sigleo, 1998; Sommaruga & Garcia-Pichel, 1999). Defence mechanisms of higher plants against UV-B damage also include scattering and reflection of UV-B radiation by epidermal and cuticular structures, photoreactivation enzymes, excision of DNA damage and scavenging of radicals, while polyamines may additionally ameliorate UV-B damage to membranes (Stapleton, 1992; Mitchell & Karentz, 1993; Runeckles & Krupa, 1994). Phytoplankton pro-

ducts itself by forming cenobia or relative larger cell size and shading vital cellular structure (Nielsen, 1996; Xiong *et al.*, 1999; Xiong 2001). The net effect of UV-B on organisms is the result of damage and repair processes and depends on the type of the environment.

Aquatic and terrestrial environments differ in many parameters essential for plant survival. Terrestrial plants have evolved structures like cuticle and stomata, which on the one hand reduce the loss of water, while on the other hand they limit uptake of carbon dioxide (CO<sub>2</sub>) from the air. The important role of epidermal and cuticular structures and other leaf properties, such as waxy layer, leaf hairs and leaf bladders, is also scattering and reflection of UV-B radiation. The main factors limiting growth and development of aquatic plants are variable light intensity and slow diffusion of CO<sub>2</sub> (Frost-Christensen & Sand-Jensen, 1992; Clevering *et al.*, 1996; Vadstrup & Madsen, 1996). Plants in aquatic and terrestrial environment are exposed to different radiation conditions, including those in the UV range. The UV-B penetration in water may vary from only few centimetres in highly humic lakes to dozens of meters in clear oceanic waters (Smith & Baker, 1981). Optical properties of water depend on water itself, dissolved organic matter (DOM), the photosynthetic biota and particulate matter (Nielsen, 1996; Williamson *et al.*, 1996; Sommaruga & Psenner, 1997; Huovinen *et al.*, 2003). Aquatic plants could be therefore partly protected from direct UV-B radiation by water filter. Phytoplankton populations are exposed to high solar UV-B level, when they are close to the water surface and when the water transparency for UV-B is high. Higher aquatic plants thriving in the littoral are exposed to UV-B when water level decreases. Amphibious plants deserve special attention in UV-B research, since they thrive at the water/land interface and therefore in contrasting environments regarding availability of water, gas and radiation (Madsen & Breinholt, 1995).

The publications on UV-B research experiments are numerous (Rozema *et al.*, 1997, 2002), but in many cases the results are not comparable due to different methodological approaches. The major problem was the radiation conditions with unrealistic UV-B doses and low ratio of photosynthetic active radiation. The aim of the present article is to compare selected responses of different primary producers exposed to the level of UV-B radiation doses based on expected future scenarios.

## MATERIAL AND METHODS

The data on the following plant species were reviewed: *Scenedesmus quadricauda* (Turp.) Bréb., *Selenastrum capricornutum* Prinz, *Sphagnum magellanicum* Brid., *Ranunculus trichophyllus* Chaix [*Batrachium trichophyllum* (Chaix) van den Bosch], *Myosotis scorpioides* L. [*M. palustris* (L.) Hill], *Ceratophyllum demersum* L., *Myriophyllum spicatum* L., *Potamogeton alpinus* Bal-

bis, *Picea abies* (L.) Karst, *Fagopyrum esculentum* Moench [*F. vulgare* T. Nees, *Polygonum fagopyrum* L.], *Pulmonaria officinalis* L. [*P. officinalis* L. subsp. *maculosa* (Hayne) Gams], *Tropaeolum majus* L. and *Picea abies* (L.) Karst. Plants were treated under similar conditions in outdoor and indoor experiments.

Higher plants were exposed to enhanced level of UV-B radiation in the semi-controlled conditions in field and indoor experiments. Phytoplankton was treated with enhanced level of UV-B in indoor experiments. Plants from the natural environment were transplanted into natural sediment in semi-controlled conditions in the Botanical Garden of Ljubljana University (46°35'N, 14°55'E), Slovenia. An UV-B supplement system was designed as described by Björn & Teramura (1993). Three different treatments were applied: simulation of 17% ozone depletion (UV-B(+)) using Q-Panel UV-B 313 lamps, filtered with cellulose diacetate filters, which cut the UV-C range (wavelengths lower than 280 nm). The second treatment reduced the ambient level of UV-B radiation (UV-B(-)) for 50% using Mylar foil, which blocks wavelengths below about 320 nm (Gehrke *et al.*, 1996). Finally, control treatment was ambient radiation and Q-Panel UV-B 313 lamps, filtered with Mylar foil, to correct for effects of the UV-A radiation (control). The doses simulating 17% ozone depletion were calculated and adjusted weekly using the program published by Björn & Murphy (1985), based on the generalized plant action spectrum (Caldwell, 1968). Ambient UV-B radiation was measured using the European Light Dosimeter Network (ELDONET, Real Time Computer, Möhrendorf, Germany) measuring system, which also monitors UV-A radiation and PAR.

Cell suspensions of *S. quadricauda* and *S. capricornutum* were cultured in polyethylene (PE) open-top (200 ml, less than 4 cm suspension layer) vessels in Jaworski medium at 23±2°C. Light sources were GROLUX lamps, which provided 200 µmol m<sup>-2</sup> s<sup>-1</sup> of PAR (12/12 hours, light/dark). The UV-B doses varied from 0.8 to 12.3 kJ m<sup>2</sup>/day, using the lamps and filters mentioned above.

#### Photosynthetic pigments and UV-B absorbing substances

Carotenoids and chlorophyll *a* and *b* were determined according to Jeffrey & Humphrey (1975). The procedure for the extraction of UV-B absorbing substances followed the method described by Caldwell (1968). UV-B absorbing substances were extracted with an extraction medium (methanol:distilled water:HCl = 79:20:1) and centrifuged. The supernatants of the samples were scanned in the range from 280-320 nm. The extinction values were corrected for dry weight of the sample.

#### Physiological parameters

The quantum efficiency of PS II (photosystem II) was

measured using the fluorometer OS-500 (Opti-Science, USA). The optimal quantum efficiency was calculated as Fv/Fm. Plants were kept in cuvettes for dark adaptation for 15 min before the measurements at ambient temperature. The effective quantum efficiency of PS II (yield - Y) was measured under actual light conditions, described by the expression  $Y = (Fm' - F)/Fm'$ . The yield was measured under full light conditions (from 1500 to 2000 µmol m<sup>-2</sup> s<sup>-1</sup>) at the prevailing ambient temperature (Schreiber *et al.*, 1995).

Respiratory potential was estimated via measuring the potential electron transport system (ETS) activity of mitochondria as reported in detail by Packard (1971) and modified by Kenner & Ahmed (1975). The material was homogenized in ice-cold homogenizing buffer and centrifuged in a refrigerated ultracentrifuge (500 g, 4 min, 0°C). The supernatant of the homogenate was mixed with substrate solution, INT solution and incubated for 40 min at room temperature. During incubation, the INT (instead of oxygen) was reduced to formazan. The absorption of formazan was measured with UV/VIS Spectrometer System (Lambda 12, Perkin-Elmer, USA) at 490 nm. The absorption was converted to the amount of oxygen utilized per dry mass per time.

#### Statistical analysis

All measurements were conducted on 4-10 parallel samples respectively. The significance of the differences was indicated as follows: (+) stands for positive trend, (++) indicates significant positive effect, (x) indicates no clear effect, and (-) negative effect. Differences were tested by two-way Student's t-test.

#### DISCUSSION

According to data from many researches, UV-B induces the bleaching of photosynthetic pigments (Strid *et al.*, 1990; Holm-Hansen *et al.*, 1993; Bischof *et al.*, 1998). Even though accessory pigments appear to be more sensitive than chlorophylls (Tevini, 1993), the destructive effect on chlorophyll has been reported by Jansen *et al.* (1996), Olsson (1999) and Demmig-Adams & Adams (1992). The latter suggest that the decrease in chlorophyll *a* is related to a kind of excess-light stress avoidance mechanism. The effect of UV-B on the content of chlorophyll *a* seems to be species specific. Several researchers (Tosserams & Rozema, 1996; Antonelli *et al.*, 1997; Garde & Cailliau, 1998) support the results obtained in our laboratory under the 17% depletion of ozone layer (Tab. 1), which showed no effect of UV-B radiation on chlorophyll *a* content. In some cases, the contents of chlorophyll *a* even increase under UV-B radiation (Liu *et al.*, 1995). Beardall *et al.* (1997) and De Lange *et al.* (2000) report a negligible effect on chlorophyll *a* in UV-B treated cells of *A. flos-aquae* and *Sele-*

*nastrum*, respectively. Veen *et al.* (1997) find a stimulation of chlorophyll *a* and *b* production in green alga *S. capricornutum*. The same effect was also found in *S. quadricauda* and *S. capricornutum* in our laboratory (Germ *et al.*, 2002a). The increase of chlorophyll *a* in *P. abies* was observed in emergent needles in spring only, when the protective mechanisms were not fully developed (Trošt & Gaberščik, 2001). The fact that the production of chlorophyll *a* was not depressed but slightly stimulated could also be explained as a protective strategy of cells. By "multiplication" of target sites, an organism avoids disturbances in the activity. Karentz *et al.* (1991) also point out the protective role of chloroplasts in the cell. Their position in the cell could provide the protection of nucleus against strong radiation.

The increase of UV-B absorbing compounds with increasing UV-B radiation dose (Shick *et al.*, 1996) suggests that UV-B induces synthesis of these substances for protection of the photosynthetic apparatus in primary producers (Hunt & McNeil, 1999; Karsten *et al.*, 1999; Turunen *et al.*, 1999). Synthesis of UV-B absorbing compounds was induced by UV-B radiation in *S. quadricauda* and in *S. capricornutum* (Tab. 1) as it had been observed for many other algae (Karentz *et al.*, 1994; Häder, 1996; Xiong *et al.*, 1999; Sommaruga, 2001; Xiong, 2001; Germ *et al.*, 2002a). Enhanced UV-B radiation also increased the production of UV-B absorbing compounds in *C. demersum* and *F. esculentum* (Gaberščik *et al.*, 2002a, b). In many cases, the production of UV-B absorbing compounds does not necessarily depend on UV-B dose (Rau & Hofmann, 1996). No correlation with the UV-B dose and synthesis of UV-B absorbing compounds was found in *R. trichophyllus*, *M. scorpioides*, *P. alpinus*, and *M. spicatum* (Germ *et al.*, 2002b). Some plants, such as those from tropical and high altitude environments, contain saturated amounts of flavonoids, and enhanced doses do not exert an increased production (Teramura & Sullivan, 1994). It is hypothesized (Sullivan *et al.*, 1996) that the receptors triggering the synthesis of UV-B absorbing compounds are saturated in plants growing in an open environment so that they provoke maximal synthesis at all irradiances. In *P. abies*, the protective mechanisms also appeared to be dependent more on the developmental state of leaf than induced by enhanced UV-B radiation. In emergent needles only, where UV-B radiation could penetrate into the mesophyll, biosynthesis of UV-B absorbing compounds was related to UV-B radiation dose (Trošt & Gaberščik, 2001). It seemed that in the studied plants the amount of UV-B absorbing compounds was sufficient, since we detected no disturbances in plant physiology (Tab. 2). None of the studied species exposed to UV-B radiation corresponding to 17% ozone depletion showed decrease of Fv/Fm ratio or Y that would reflect disturbance in photosynthesis. It is also likely that the damage caused by UV-B radiation is efficiently repaired (Rozema *et al.*, 1997). On the contrary, many authors re-

port about the effects of UV-B radiation on photochemical efficiency of PS II (Schoefield *et al.*, 1995; Häder *et al.*, 1996; Xiong *et al.*, 1999; Xiong, 2001.)

**Tab. 1: The influence of enhanced UV-B radiation content of chlorophyll *a*, carotenoids and UV-B absorbing compounds (UV-B AC). Legend: + indicates positive trend, ++ indicates significant positive effect, x indicates no clear effect, - stands for negative effect (n = 4-10, p < 0.05).**

**Tab. 1: Vpliv povečanega UV-B sevanja na vsebnost klorofila *a*, karotenoidov in UV-B absorbirajočih snovi (UV-B AC). Legenda: + označuje pozitivno težnjo, ++ označuje značilno pozitiven vpliv, x označuje nejasen vpliv, - označuje negativen vpliv (n = 4-10, p < 0,05).**

Species	Chl <i>a</i>	Carotenoids	UV-B AC	Source
<i>S. quadricauda</i>	+		++	Germ <i>et al.</i> , 2002a
<i>S. capricornutum</i>	+		++	not published
<i>S. magelanicum</i>	x	x	x	not published
<i>R. trichophyllus</i>	x	x	x	Germ <i>et al.</i> , 2002b
<i>C. demersum</i>	+ /		++ / +	not published / Gaberščik <i>et al.</i> , 2002a
<i>M. spicatum</i>	x	x	x	not published
<i>P. alpinus</i>	x	x	x	Germ <i>et al.</i> , 2002b
<i>M. scorpioides</i>	x	x	x	not published
<i>F. esculentum</i>	x	+	+	Gaberščik <i>et al.</i> , 2002b
<i>P. officinalis</i>	x	x	x	Gaberščik <i>et al.</i> , 2001
<i>T. majus</i>	x	x	+	not published
<i>P. abies</i>	+, x		+, x	Trošt & Gaberščik, 2001

**Tab. 2: The influence of enhanced UV-B radiation on Fv/Fm ratio, yield and ETS activity. Legend: + indicates positive trend, ++ indicates significant positive effect, x indicates no clear effect, - stands for negative effect (n = 4-10, p < 0.05).**

**Tab. 2: Vpliv povečanega UV-B sevanja na razmerje Fv/Fm, učinkovitost in aktivnost ETS. Legenda: + označuje pozitivno težnjo, ++ označuje značilno pozitiven vpliv, x označuje nejasen vpliv, - označuje negativen vpliv (n = 4-10, p < 0,05).**

Species	Fv/Fm	Yield	ETS	Source
<i>S. quadricauda</i>			++	Germ <i>et al.</i> , 2002a
<i>S. capricornutum</i>			++	not published
<i>S. magelanicum</i>	x	x	x	not published
<i>R. trichophyllus</i>	x	x	x	Germ <i>et al.</i> , 2002b
<i>C. demersum</i>	x /	x /	++	not published / Gaberščik <i>et al.</i> , 2002a
<i>M. spicatum</i>	x	x	x	not published
<i>P. alpinus</i>	x	x	x	Germ <i>et al.</i> , 2002b
<i>M. scorpioides</i>	x	x	x	not published
<i>F. esculentum</i>	x	x		Gaberščik <i>et al.</i> , 2002b
<i>P. officinalis</i>	x	x		Gaberščik <i>et al.</i> , 2001
<i>T. majus</i>	x	x		not published
<i>P. abies</i>	x	x	+, x	Trošt & Gaberščik, 2001

The production of photosynthetic pigments and UV-B absorbing compounds demanded an additional supply of energy, which was provided by increased respiratory

potential. The relation between the amount of UV-B absorbing compounds and ETS activity was significantly positive as reported for *S. quadricauda* and *C. demersum* (Tab. 2) (Gaberščik *et al.*, 2002a). Increased ETS activity under enhanced UV-B radiation therefore augmented the energetic cost involved in generating the internal mechanisms of photoprotection (Ferreira *et al.*, 1997; Scott *et al.*, 1999; Gaberščik *et al.*, 2002a).

### SUMMARY

Enhanced UV-B radiation due to thinning of the stratospheric ozone layer affects primary producers. The research carried out on many species under similar experimental conditions, *i.e.* doses corresponding to 17% ozone depletion, showed species specific responses. Data from literature are very controversial. The contents of chlorophyll *a* were increased in algae *S. quadricauda* and *S. capricornutum* and in submersed macrophyte *C. demersum*. The increase of chlorophyll *a* in *P. abies* was observed in spring only, when the protective mechanisms were not fully developed. Other species showed no evident changes in chlorophyll content. The increase of UV-B absorbing compounds with increasing UV-B radiation dose is the most frequent reaction to UV-B radiation reported in literature. It has been observed for many algae, as well as for *S. quadricauda* and *S. capricornutum*. UV-B radiation also induced production of UV-B absorbing compounds in higher plants *C. demersum* and *F. esculentum*. In many cases, the production of UV-B absorbing compounds does not necessarily depend on UV-B dose. No correlation with the UV-B dose was detected in aquatic plants *R. trichophyllum*, *M. scorpioides*, *P. alpinus*, and *M. spicatum*. It was hypothesized that the receptors triggering the synthesis of UV-B absorbing compounds are saturated in plants growing in

an open environment, thus provoking maximal synthesis at all irradiances. In *P. abies*, the production of UV-B absorbing compounds appeared to be dependent more on the developmental state of leaf than induced by enhanced UV-B radiation. In emergent needles only, where UV-B radiation could penetrate into the mesophyll, biosynthesis of UV-B absorbing compounds was related to UV-B radiation. Many authors report about the effect of UV-B radiation on photochemical efficiency of PS II. None of the studied species exposed to UV-B radiation corresponding to 17% ozone depletion showed decrease of Fv/Fm ratio or Y, which would reflect disturbance in photosynthesis. The production of UV-B absorbing compounds demanded an additional supply of energy, which was provided by higher respiratory potential. The relation between the amount of UV-B absorbing compounds and ETS activity was significantly positive, as reported for *S. quadricauda*, *S. capricornutum* and *C. demersum*. The increased ETS activity under enhanced UV-B radiation therefore provided additional energy needed for the establishment of photoprotection and photorepair mechanisms.

### ACKNOWLEDGEMENTS

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## VPLIV UV-B SEVANJA NA VODNE IN KOPENSKE PRIMARNE PROIZVAJALCE

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### POVZETEK

Povečano UV-B sevanje, ki je posledica tanjšanja ozonske plasti, vpliva na primarne proizvajalce. Raziskave



kažejo, da so se različne vrste, izpostavljene odmerkom, ki ustrezajo približno 17% stanjšanju ozonske plasti, odzvale različno. Rezultati o vplivu UV-B sevanja na primarne proizvajalce si pogosto nasprotujejo. Vsebnost klorofila a je pod vplivom UV-B sevanja narasla pri algah vrste *Scenedesmus quadricauda* in *Selenastrum capricornutum* ter pri podvodni rastlini navadni rogoлист *Ceratophyllum demersum*. Naraščanje vsebnosti klorofila a pri navadni smreki *Picea abies* smo opazili samo spomladi, ko zaščitni mehanizmi še niso bili popolnoma razviti. Druge vrste, ki smo jih preučevali, niso kazale jasnega vpliva UV-B sevanja na vsebnost klorofila a. Glede na podatke v literaturi je naraščanje UV-B zaščitnih snovi najbolj pogost odziv primarnih proizvajalcev na povečano UV-B sevanje. UV-B sevanje je vplivalo na izgradnjo UV-B zaščitnih snovi tudi pri vrstah *S. quadricauda* in *S. capricornutum* in višjih rastlinah, kot sta navadni rogoлист *C. demersum* in navadna ajda *Fagopyrum esculentum*. V mnogih primerih pa izgradnja UV-B zaščitnih snovi ni odvisna od odmerka UV-B sevanja. Korelacije med vsebnostjo UV-B zaščitnih snovi in odmerkom UV-B sevanja ni bilo pri lasastolistni vodni zlatici *Ranunculus trichophyllus*, alpskem dristavcu *Potamogeton alpinus* in klasastem rmancu *Myriophyllum spicatum*. Predpostavljamo, da so receptorji, ki vplivajo na izgradnjo UV-B zaščitnih snovi, nasičeni pri rastlinah, ki rastejo na odprtih rastiščih in tako omogočajo maksimalno izgradnjo pri različni intenziteti obsevanja. Pri navadni smreki *P. abies* je videti, da je bila izgradnja UV-B zaščitnih snovi bolj odvisna od razvojnega stanja iglic kot od povečanega UV-B sevanja. Izgradnja UV-B zaščitnih snovi je bila povezana z UV-B sevanjem samo pri nerazvitih iglicah, kjer je UV-B sevanje prodiralo do mezofila. Mnogi avtorji so dokazali vpliv UV-B sevanja na fotokemično učinkovitost fotosistema II (FS II). V naši raziskavi nobena od preučevanih vrst ni pokazala vpliva UV-B sevanja, ki ustreza 17% simulaciji tanjšanja ozonske plasti, na zmanjšanje potencialne fotokemične učinkovitosti (Fv/Fm), ali dejanske fotokemične učinkovitosti (angl. yield), ki kažejo na motnje v procesu fotosinteze. Izgradnja UV-B zaščitnih snovi zahteva dodatno zalogo energije, ki si jo organizmi zagotovijo s povečanim dihalnim potencialom (aktivnost ETS). Razmerje med vsebnostjo UV-B zaščitnih snovi in aktivnostjo ETS je bila značilno pozitivna pri vrstah *S. quadricauda*, *S. capricornutum* in navadnem rogolistu *C. demersum*. Povečana aktivnost ETS pri organizmih, ki so bili izpostavljeni povečanemu UV-B sevanju, je zagotovila dodatno energijo za vzpostavitev fotozaščite in fotopopravljalnih mehanizmov.

**Ključne besede:** UV-B sevanje, primarni proizvajalci, UV-B absorbirajoče snovi, fotokemična učinkovitost FS II, aktivnost terminalnega elektronskega transporta

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## NEXUS BETWEEN THE MOTOR PERFORMANCE AND COGNITIVE ABILITIES OF PRE-SCHOOL GIRLS

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### ABSTRACT

*The main objective of the present study was to establish whether there are connections between the motor performance and cognitive abilities of pre-school girls. The sample of tested children included 138 girls, aged five. The psychological part of the testing was implemented with the test RAZKOL. The girls were tested with 28 tests for measuring motor abilities. The results show that there is a positive correlation between the motor performance and cognitive abilities. The motor variables that show the highest correlations with cognitive variable are those having the characteristics of movement coordination, speed of movement and explosive strength. The results confirm the arguments that it is reasonable to treat the anthropological dimensions as components of an integral and organized system.*

**Key words:** motor performance, cognitive abilities, nexus, pre-school girls

## NESSO TRA PRESTAZIONI MOTORIE ED ABILITÀ COGNITIVE DI BIMBE IN ETÀ PRESCOLARE

### SINTESI

*Lo scopo principale del presente studio è stato quello di stabilire eventuali nessi tra prestazioni motorie ed abilità cognitive in bimbe in età prescolare. Il campione considerato ha compreso 138 bimbe di 5 anni di età. La parte psicologica della verifica è stata eseguita con il test RAZKOL. Al fine di valutare le abilità motorie, le bimbe sono state sottoposte a 28 test. I risultati indicano che esistono correlazioni positive tra prestazioni motorie ed abilità cognitive. Le variabili motorie che hanno evidenziato maggiori correlazioni con le variabili cognitive sono quelle con caratteristiche di coordinazione del movimento, velocità del movimento e forza esplosiva. I risultati confermano l'ipotesi che nel bambino bisogna considerare le differenti dimensioni antropologiche come parti integranti di un sistema completo ed organizzato.*

**Parole chiave:** capacità motorie, capacità cognitive, nesso, bimbe in età prescolare

## INTRODUCTION

The functioning of the whole human psychosomatic system, as well as the individual dimensions of this system, is to a great extent connected with the relation between these dimensions.

The question has often been posed about the nature of the relationship between human motor performance and cognitive abilities. A more detailed analysis of this relationship is of particular importance with regard to children who are in the phase of dynamic development, since its results enable a better explanation of complex developmental processes. A better understanding of the laws of the motor development requires an exploration into motor dimensions and their relationship with other psychosomatic dimensions.

The main objective of the present study was to establish whether there are connections between the motor performance and cognitive abilities of pre-school girls and, in case it is established that they do exist, to analyse them in greater detail. The questions connected with samples of a similar age group have been treated by several researchers (e.g. Leithwood, 1971; Thomas & Chisom, 1972; Eggert & Schuck, 1978; Dickes, 1978; Zimmer, 1981; Madić, 1986; Clymer & Silva, 1988; Strel & Žagar, 1993; Krombholz, 1997; Planinšec, 2001), who have determined a positive correlation between motor and cognitive abilities. However, comparisons of their studies are almost impossible, as they use different samples of tested persons, battery of tests and data processing and offer different interpretations of the obtained results.

Researches established there are two groups of factors that are important for the connections between motor and cognitive abilities. When a motor task does not contain problem situations, the connection can be explained by the speed of the information flow in the nervous system (e.g. Mejovšek, 1977; Mohan & Bhatia 1989; Reed & Jensen, 1991; Vernon & Mori, 1992). On the other hand, when a motor task does present a problem, the connection can be explained by the cognitive activities during the solving of a motor problem (Mejovšek, 1977; Planinšec, 2001).

In our opinion, a relatively big problem with pre-school children is posed by the implementation of testing, which causes more complications at this age than with older subjects. Pre-school children make a relatively great number of mistakes in the implementation of test tasks, which is particularly true of more demanding motor tasks. It can be concluded that certain problems connected with the implementation of test tasks by pre-school children simply cannot be avoided, which has also been established by other authors (Pišot, 1997; Rajtmajer, 2000).

Researchers have found that there are significant gender-related differences with regard to motor abilities

(Thomas & French, 1985; Rajtmajer, 1993; Rajtmajer & Pišot, 1999). In spite of the conclusions that there are no greater gender-related differences with regard to the relations between cognitive and psychomotor abilities (Carretta & Ree, 1996; Planinšec, 2001), it is necessary to carry out the study separately according to gender, particularly when the study involves young children. For this reason, the sample of the study presented below includes only girls.

## METHODS

Tests were performed within the framework of the research project that has been in existence for several years as cooperation between the Faculty of Education and the Health Clinic of Maribor (Slovenia).

### Participants

The sample comprised 138 girls, coming from north-east Slovenia. The average age of girls was exactly five. The selection of girls for the sample was random.

### Cognitive test

The psychological part of the testing was implemented with the test RAZKOL (Praper, 1981) that has been standardized on the Slovenian population of pre-school children. Test tasks are the following: drawing, matching of objects and geometric shapes, repetition of numbers, words and sentences, logical completion of sentences, the fulfilment of a sequence of commands, analogy of opposites, the recognition of the doer, the finding of differences, definition of usage, the understanding of numbers, and simple calculation. The exercises are adapted to different age periods and they increase according to the level of difficulty. During testing, different instruments were used. The test gives a global assessment of an individual's cognitive abilities, using verbal and non-verbal test tasks, while the results of the tests depend on the relation between the mental and chronological age of the individual.

### Motor tests

28 tests were used for measuring the children's motor abilities (Rajtmajer & Proje, 1990), which have also been standardized on the Slovenian population and are appropriate for use on the chosen sample of tested girls. Motor tests belong to the following hypothetical dimensions: whole-body coordination (rolling the ball around the hoop, walking on rungs backwards, walking through hoops backwards, polygon backward, crawling under the bench, crawling with a ball, running after crawling), hand coordination (circulating the ball around the body, rolling the ball around the feet, leading the ball with two

hands in a standing position, building a tower from big foam rubber cubes, building with hollow cubes, building a tower from small wooden cubes), agility (stepping sideways, running with changing directions, running in a zigzag), explosive strength (standing long jump, standing triple jump, standing high jump), repetitive strength (stepping on a bench, sideways jumps, sideways jumps with hand support), speed of simple movements (hand tapping - two fields, foot tapping, hand tapping - 4 fields), balance (standing on a block longitudinally, standing on a block crosswise, standing on a vertical block). The girls carried out three repetitions of each motor test.

### Procedure

The measurements of motor and cognitive abilities were always carried out in specially prepared rooms. The entire testing of one child did not exceed two hours. The measurements were carried out by qualified experts.

### Statistics

The data was processed on PC with SPSS statistical program. Motor variables were treated in latent and manifest space. Factor analysis was used for establishing the latent space of motor dimensions. The determination of the number of important principal components was based on the Kaiser-Guttman criterion ( $\lambda > 1$ ). The simpler definition of the structure of motor factors was based on the rotation of factors with the oblimin method. The relation between motor and cognitive variables was calculated using the method of multiple regression analysis. The system of predictors was represented by two groups of the motor variables: the first group contains the manifest variables, and the second group the latent factors. The criterion was in both cases represented by the result of the cognitive test.

### RESULTS

The results show that there is a positive correlation between the motor and cognitive variables. In the first case (Tab. 1) there is a statistically significant correlation ( $p = 0.00$ ) between the whole system of manifest motor variables and the cognitive variable. The coefficient of multiple correlation is quite high ( $R = 0.58$ ). Between the motor and cognitive variables there is 33% of common variance ( $R^2 = 0.33$ ). The individual motor variables which have a statistically significant correlation with the cognitive variable on the  $p < 0.05$  level are the following: building with hollow cubes ( $\beta = 0.270$ ), foot tapping ( $\beta = 0.229$ ), standing triple jump ( $\beta = 0.217$ ), running with changing directions ( $\beta = 0.196$ ), running after crawling ( $\beta = 0.184$ ), and walking on rungs backwards ( $\beta = 0.171$ ).

**Tab 1: Summary of regression analysis for manifest motor variables and cognitive variable ( $\beta$  – standardized coefficient of partial regression;  $p$  – the level of statistical significance;  $R$  – coefficient of multiple correlation;  $R^2$  – coefficient of determination).**

**Tab. 1: Povzetek regresijske analize motoričnih in kognitivnih spremenljivk ( $\beta$  – standardiziran koeficient delne regresije;  $p$  – raven statistične pomembnosti;  $R$  – koeficient večkratne korelacije;  $R^2$  – koeficient determinacije).**

No.	Motor variable	$\beta$	$p$
1	Building a tower from big foam rubber cubes	.017	.8324
2	Standing on a block longitudinally	.084	.3424
3	Standing high jump	.025	.7433
4	Hand tapping - two fields	.039	.5790
5	Rolling the ball around the feet	-.002	.9709
6	Crawling with a ball	-.034	.6594
7	Running with changing directions	-.196	.0423*
8	Standing on a vertical block	-.035	.6524
9	Standing triple jump	.217	.0189*
10	Stepping on a bench	.071	.4346
11	Running after crawling	-.184	.0180*
12	Building with hollow cubes	-.270	.0004*
13	Sideways jumps	-.025	.8036
14	Walking on rungs backwards	.171	.0288*
15	Stepping sideways	.121	.2240
16	Leading the ball with two hands	-.101	.1879
17	Running in a zigzag	-.054	.4548
18	Crawling under the bench	.112	.1924
19	Standing on a block crosswise	.061	.5048
20	Sideways jumps with hand support	-.049	.6178
21	Walking through hoops backwards	.050	.6391
22	Rolling the ball around the hoop	-.009	.9027
23	Building a tower from small wooden cubes	-.102	.2163
24	Foot tapping	.229	.0055*
25	Hand tapping - 4 fields	.111	.2112
26	Circulating the ball around the body	-.150	.0797
27	Standing long jump	.008	.9272
28	Polygon backward	.007	.9488
$R^2 = .335, R = .578, p = .0000$			

\* $p \leq .05$

With the method of factor analysis, 8 motor factors were extracted. These factors are: speed of simple movements (Factor 1), balance (Factor 2), agility (Factor 3), speed of complex movements (Factor 4), explosive strength (Factor 5), eye-hand coordination (Factor 6), whole-body coordination (Factor 7), hand coordination (Factor 8). The obtained factors were used in the regression analysis. In this case (Tab. 2), there is a statistically significant correlation ( $p = 0.00$ ) between the whole system of motor factors and the cognitive variable. The coefficient of multiple correlation is slightly lower ( $R = 0.40$ ). There is 16% of common variance ( $R^2 = 0.16$ ) between the motor factors and the cognitive variable. Among the motor variables, six factors have a statistically significant correlation with the cognitive variable



on the  $p < 0.05$  level: speed of simple movements ( $\beta = 0.239$ ), speed of complex movements ( $\beta = 0.216$ ), explosive strength ( $\beta = 0.207$ ), eye-hand coordination ( $\beta = 0.180$ ), whole-body coordination ( $\beta = 0.129$ ), and hand coordination ( $\beta = 0.167$ ).

**Tab. 2: Summary of regression analysis for motor factors and cognitive variable ( $\beta$  – standardized coefficient of partial regression;  $p$  – the level of statistical significance;  $R$  – coefficient of multiple correlation;  $R^2$  – coefficient of determination).**

**Tab. 2: Povzetek regresijske analize motoričnih faktorjev in kognitivne spremenljivke ( $\beta$  – standardiziran koeficient delne regresije;  $p$  – raven statistične pomembnosti;  $R$  – koeficient večkratne korelacije;  $R^2$  – koeficient determinacije).**

No.	Motor factor	$\beta$	$p$
1	Speed of simple movements	.239	.0016*
2	Balance	.063	.3523
3	Agility	.117	.0882
4	Speed of complex movements	-.216	.0018*
5	Explosive strength	.207	.0053*
6	Eye-hand coordination	-.180	.0114*
7	Whole-body coordination	-.129	.0501*
8	Hand coordination	-.167	.0208*
$R^2 = .165, R = .407, p = .0001$			

\*  $p \leq .05$

## DISCUSSION

The results of both regression analyses show that the significant and highest correlation coefficients with the cognitive variable have the motor variables, in which the characteristics of movement coordination, the speed of movement and explosive strength are generally predominant. On the basis of the obtained results we can explain the connections between motor performance and cognitive abilities with different causes.

The connection between the coordination of movement and cognitive abilities has been established in pre-school children by several researchers (Leithwood, 1971; Clymer & Silva, 1988; Pišot, 1999, 2000; Planinšec, 2001). An important part of the variance of coordination abilities is explained by the cognitive factors of dynamic visual processing, visuo-spatial processing, working memory, and partly processing speed (Tirre & Raouf, 1998). Coordinational complex movements (Variables: running with changing directions, building with hollow cubes, walking on rungs backwards, running after crawling; Factors: eye-hand coordination, whole-body coordination, hand coordination) require cognitive activity for the recognition and formation of an effective motor program on the basis of which movement tasks is implemented. And during the implementation of movement the motor program has to be

adapted to different (intrinsic and extrinsic) feedback information. All this requires the integration of information and the integration of functions that are necessary for a successful processing of information, which in turn constitutes the basis of cognitive activity. The implementation of informationally complex movement tasks involves problem situations that have to be effectively solved, and this requires cognitive activity.

In the case where the predominant characteristic of motor variables is the speed of simple movements (Variable: foot tapping; Factor: speed of simple movements, speed of complex movements), the connection between motor and cognitive variables can be explained mainly by the general speed of the information flow in the nervous system, which enables a quick and effective communication among different areas of the central and peripheral nervous system and is very important for the efficacy of motor and cognitive processes. Our assumptions are somehow confirmed by the findings of Reed & Jensen (1991) and Vernon & Mori (1992), who established that there is a positive correlation between the measure of intelligence and the measure of nerve conduction velocity.

The connection between the variables of explosive strength (Variable: standing triple jump; Factor: explosive strength) and cognitive variables is somewhat surprising, and it can be ascribed to various factors. To the motor dimension of explosive strength belong the following tests: standing long jump, standing triple jump and vertical jump, i.e. tasks with predominant leg movement. These are obviously tasks that require, among other things, a complex structured motor action. In general, the children of this age probably do not have this kind of specific experience and such movements present a kind of problem situation to them. It should be noted that similar results were obtained by Madić (1986), who established that the connection of this kind is due to the ontogenetic development. Motor programs for leg are formed later than those for arm, which is why carrying out motor tasks in which leg movement is predominant requires high level of motor control. It seems that at the age of 5 the cognitive activities are probably important for complex leg movements as well. In addition to this, factor of explosive strength has a strong correlation with the factors of movement coordination and the speed of movement, which are also connected with cognitive abilities.

A comparison between the results of both regression analyses shows that the coefficient of the multiple correlation attains a higher value when the system of predictors is represented by manifest motor variables. This is perfectly logical, since the factor analysis accomplishes a reduction of data, which obviously has an important influence on the decrease of the level of correlation. On the other hand, we have established that out of 8 motor factors there are 6 of those that have statisti-

cally significant correlation coefficients with the cognitive variable. This can be explained by the fact that the motor factors present abilities with a wider range of activities, in which a greater number of different factors play an important role, including cognitive factors.

### CONCLUSIONS

The results obtained on a sample of Slovenian pre-school girls have confirmed the assumptions about the existence of a positive correlation between motor per-

formance and cognitive abilities. The fact is that in the course of development, changes occur in individual human abilities as well as in the relation between them. In the future it will thus be necessary to establish how the relation between motor performance and cognitive abilities changes. This will require similar analyses with the same tests on samples differing according to age, and the same will be necessary for a sample of boys. The above results confirm the arguments that it is reasonable to treat all the anthropological dimensions as components of an integral and organized system.

## POVEZANOST MED MOTORIČNO UČINKOVITOSTJO IN KOGNITIVNIMI SPOSOBNOSTMI PREDŠOLSKIH DEKLIC

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### POVZETEK

Glavni namen raziskave je bil ugotoviti, ali obstaja povezanost med motoričnimi in kognitivnimi sposobnostmi pri deklicah v predšolskem obdobju. Vzorec je obsegal 138 deklic, starih natančno 5 let. Psihološki del meritev je bil opravljen s testom RAZKOL. Za oceno motoričnih sposobnosti je bilo uporabljenih osemindvajset testov. Relacije med motoričnimi in kognitivnimi spremenljivkami so bile izračunane z metodo multiple regresijske analize. Rezultati kažejo, da obstaja pozitivna povezanost med motoričnimi in kognitivnimi sposobnostmi. Motorične spremenljivke, ki kažejo najvišje korelacije s kognitivno spremenljivko, imajo značilnosti koordinacije gibanja, hitrosti gibanja in eksplozivne moči. Rezultati potrjujejo predvidevanja, da je pri otroku treba upoštevati različne antropološke dimenzije kot sestavne dele celovitega in organiziranega sistema.

**Ključne besede:** motorične sposobnosti, kognitivne sposobnosti, povezanost, predšolske deklice

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**DELO NAŠIH ZAVODOV IN DRUŠTEV**

**ATTIVITÀ DEI NOSTRI ISTITUTI E DELLE NOSTRE SOCIETÀ**

**ACTIVITIES BY OUR INSTITUTIONS AND ASSOCIATIONS**



**DELO NAŠIH ZAVODOV IN DRUŠTEV  
ATTIVITÀ DEI NOSTRI ISTITUTI E DELLE  
NOSTRE SOCIETÀ  
ACTIVITIES BY OUR INSTITUTIONS  
AND ASSOCIATIONS**

**FIRST STEPS IN ESTABLISHING THE SLOVENIAN  
NATIONAL BIOPLATFORM**

On January 15<sup>th</sup> and 16<sup>th</sup> 2003, an international exchange of project proposals was taking place in the Biology Centre, Ljubljana within the framework of the regional initiative called TriCo, which is to aid the collaboration in research and development within the Alps-Adria Region. The exchange – the 7<sup>th</sup> so far and carrying the title "Sustainable spatial planning and vulnerable ecosystems" – was much more comprehensive than the previous meetings, for parallel to the project presentation, a scientific conference within the framework of the 5<sup>th</sup> basic programme of the EU "Bioplatfrom" project was taking place. At the scientific conference, research groups from further 14 European countries were taking part, in addition to the researchers and experts from the six countries of the Alps-Adria region. More than 180 researchers from 20 countries also participated, simultaneously with the exchange of project proposals on the subject of "Sustainable spatial planning and vulnerable ecosystems", in the preparations of scientific background in the establishment of Slovenian national platform for the research in the sphere of biodiversity, which eventually became a member of the EU network. The European network of national bioplatforms is functioning within the forum called EPBRS ("European Platform for Biodiversity Research Strategy"), which serves as a bridge between the European policy making and directives in the sphere of sustainable development as well as between the research sphere and impacts of the sustainable economic development on biodiversity in Europe. Integration of experts from the EU countries in this sphere actively aids the candidate countries also in the surmounting of difficulties in the implementation of European directives and in the preparation of regionally specific contents in the sustainable development and its impact on the environment.

Within the framework of the above mentioned international exchange, the founding meeting of the Slovenian national platform for the research in the sphere of biodiversity also took part, i.e. of the forum for the stipulation and direction of development strategy and identification of priority research in the sphere of biodiversity in Slovenia, at which we, the participants, founded the Slovenian National Bioplatfrom (SNB), which is to bring together various experts from the spheres of biology, spatial planning, sustainable development, biodiversity and representative of the ministries

contributing towards the national policy making in the field of development and research.

The planners of the European Platform for Biodiversity Research Strategy (EPBRS) have come out with 4 concrete objectives, towards which national bioplatforms are to contribute as well:

1. Monitoring of the development of the European bioplatfrom through inclusion of platforms from all 32 countries (within the RTD programme), and integration of national platforms with other European and international organisations with the intention to promote the common European area of biodiversity research;

2. Organisation of 5 EPBRS meetings;

3. Organisation of electronic conferences before the meetings, at which a wide range of users would discuss the selected topics, and

4. Reports on findings, discoveries and other EPBRS results.

The main objectives of the Slovenian National Bioplatfrom are activities dealing with the preparation of the national strategy for biodiversity research, preparation of interdisciplinary research programmes and definition of priority tasks, integration with other national bioplatforms and the European platform, identification of the good and the bad aspects of development, inclusion of Slovenian research into international programmes, and a series of other activities associated with it. The fact is that Slovenia is faced, similar as other Central and Eastern European countries, with some major problems, such as shortage of taxonomy specialists, lack of strategy of this kind, modest financial support to the classical research in the sphere of biodiversity, lack of communication between scientific institutions and professional non-government organisations dealing with similar subjects, and concordance between competent ministries regarding the developmental-spatial and sectorial activities, which have a potential impact on biodiversity as well as on the outer appearance of cultural and natural landscape in Slovenia. In Europe, Slovenia is known as its "hot spot" with extremely high biodiversity, due to which it is highly important that the greatest possible attention is dedicated to this complexity.

Last but not least, the strategy of economic growth in Slovenia and its tourist development is based on the conservation of natural wealth and biodiversity, which is due to the country's position at the junction of very diverse climatic-geological belts in fact unique in Europe. Exceptionally important for the survival and further development of SNB is also the support given by the Ministry of Environment, Spatial Planning and Energy and the goodwill of Minister Janez Kopač, who in his address given during the opening of the international exchange in the Biology Centre in Ljubljana on the subject of sustainable spatial management and vulnerable ecosystems gave his full support to the SNB and its successful functioning.



At the founding meeting in Ljubljana, its participants agreed that within the framework of the founding activities of the Slovenian National Bioplatform they would initially name a number of experts from various scientific-research institutions, prepare a list of professional institutions and non-governmental organisations connected with the biodiversity research in Slovenia and a list of experts at the competent ministries. These lists will be applicable during the setting up of the so-called "Slovenian Biodiversity Network". In the following phase we intend to prepare a catalogue of the current research and applicative projects in the field of biodiversity and systematic monitoring of interventions into our natural environment. With the support given by the Ministry of School Education, Science and Sports, the Slovenian National Bioplatform has been enabled, as early as during its establishment, to appear on the World-Wide Web. Within the framework of the ministerial websites [www.rtd.si](http://www.rtd.si) earmarked for information on research programmes, call for tenders in the national research programme and target research programmes, we have given information support to the SNB with all the necessary links to the suitable international websites. The SNB website works within the information framework covering the research activities by the EU and the Republic of Slovenia in the field of sustainable development and global changes in the EU's 6<sup>th</sup> general programme.

The participants of the SNB's founding meeting in Ljubljana in January 2003 believed that the establishment of SNB is an exceptional opportunity for further integration and communication of the Slovenian professional public, which is any possible way associated with biodiversity, but at the same time represents a forum for reconciliation of the priority research projects.

**Aleš Gnamuš**  
**Lovrenc Lipej**

#### REPORT ON ACTIVITIES FOR LONG-TERM CONSERVATION OF THE *POSIDONIA OCEANICA* MEADOW IN SLOVENIA



*Posidonia oceanica* (L.) Delile is, together with *Cymodocea nodosa* (U.) Ascherson, the most common seagrass in the Mediterranean. It is widespread in the entire basin, except in the area close to the Strait of Gibraltar, Northern Adriatic, coastal waters of Israel, Bosphorus, Sea of Marmara, and the Black Sea. Accord-

ing to Benacchio (1938), it used to be quite common also on the silty bottom of the Gulf of Trieste in the Northern Adriatic. Further investigations showed, however, a drastic change in its distribution in this northernmost part of the Adriatic. It is very likely that at present there is only one very restricted meadow of *P. oceanica* in the Gulf of Trieste. The area is in Slovene coastal waters between the towns of Koper and Izola. A preliminary and approximate mapping of the area carried out in 1993 showed that the meadow is approximately 1 km long, starting close to the coastline (water depth from 0.2 to 0.5 m) and extending 50 m from the shore (water depth app. 4 m). The meadow consists of several *P. oceanica* islands of different sizes and shapes and does not fit into normal meadow types.

The meadow has been included in the local physical plans as a future protected area. At the same time the Slovene government decreed *P. oceanica* a rare and endangered species; the decree was adopted by the national parliament in 2002. Furthermore, *P. oceanica* is listed in Annex II of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean as endangered species, while the EU Habitat Directive 92/43/EEC of 21<sup>st</sup> of May 1992 defines its meadows as priority habitat type. The protection of *P. oceanica* and its meadows is thus one of the top priorities in the sphere of nature conservation. However, in order to suitably define the potential threats and apply efficient conservation measures for this unique meadow, further research and monitoring were necessary.

The importance of further research and monitoring is even greater due to the planned changes concerning the main coastal road that at present runs virtually along the coastline. The new road, which is bound to be built in the forthcoming years, will be shifted into a tunnel and will, as a consequence, "free" the coastline and make it available for other activities, mainly recreation and tourism. Due to it, increased pressure for beach enlargement, piers, maritime traffic and other recreational and tourist facilities is expected. Without suitable legislation, accurate maps of the sea floor and its habitat types, a well-defined monitoring and awareness campaign, the expected pressure for the development of recreational facilities could jeopardise the conservation of the meadow.

Within the framework of the SAP BIO project (Strategic Action Plan for the Conservation of Marine and Coastal Biodiversity in the Mediterranean Region), carried out by the Regional Activity Centre for Specially Protected Areas in Tunis, National Reports were prepared in order to define the state of art in the field of biodiversity conservation and to foresee the due future activities. In the Slovene National Report, 14 priority actions were listed, including activities concerning legal protection, research and monitoring programme for *P. oceanica*. As a follow-up of the National Report, a Na-

tional Action Plan for the conservation of the *P. oceanica* meadow was drafted. Its main objectives are in line with the RAC/SPA Action Plan for the conservation of marine vegetation in the Mediterranean Sea, adopted by the contracting parties to the Barcelona Convention in 1999 and with the provisions of the EU Habitat directive. The main targets of the action plan could be summed as follows:

- legal protection of *P. oceanica* and establishment of a protected area that would enclose the dealt with meadow;
- better knowledge of the extension of the area covered by *P. oceanica* based on accurate cartography of the meadow;
- better knowledge of the main ecological parameters in the area covered by the meadow;
- public awareness raising.

#### Memorandum of Understanding

The possibility to carry out most of the activities, foreseen in the action plan, came with the signing of the Memorandum of Understanding (referred hereafter as MoU) by the Institute of the Republic of Slovenia for Nature Conservation, the International Cooperation for Environment and Development of the Principality of Monaco, and the Regional Activity Centre for Specially Protected Areas (RAC/SPA) of the Barcelona Convention. According to MoU, the Institute of the Republic of Slovenia for Nature Conservation should carry out, through its Regional Office Piran, various activities aimed at providing for efficient, long-term conservation of the *P. oceanica* meadow, by which it would fulfil some of the actions foreseen in the Action Plan for the Conservation of Marine Vegetation in the Mediterranean Sea. To undertake this activities, financial support is to be granted by the International Cooperation for Environment and Development of the Principality of Monaco and RAC/SPA.

#### Implementation of the activities

The activities foreseen in the action plan and financed according to MoU were carried out in 2003. The Regional Office in Piran coordinated all the activities and at the same time attempted to "use" them as a tool to increase public awareness concerning nature conservation. A short description of the activities is given hereafter.

#### Aerial photography

Mapping of seagrass meadows has become and indispensable tool not only for developing and managing the coastal area but also for a proper research and monitoring of the meadows' structure and dynamics in

view of their management and protection. Aerial photography and further image processing appears to be a technique particularly suitable in shallow waters, as it is the case of the investigated *P. oceanica* meadow. The aerial photographs were taken and processed in the winter of 2002/2003 in order to ensure greater transparency of the water and at the same time to take advantage of the "absence" of *Cymodocea nodosa* meadows. The results of aerial photography were checked later on by SCUBA diving. On the basis of aerial photos and field data, a map of the meadow was made. The task was carried out in collaboration with the Group for Coastal Ecosystems at the University of Corte (Corsica). The mapping of the meadow, together with other activities such as marking the lower limit, will allow us to prepare a long-term monitoring programme for the meadow and other habitat types present in the area.

#### Study of the main ecological parameters in the meadow

In order to improve our knowledge on the environmental conditions that influence the development of the meadow, a programme for the study of the main ecological parameters was prepared in collaboration with the National Institute of Biology – Marine Biology Station in Piran. The investigation, which was carried out twice – in the winter and summer of 2003 – included investigation of the following parameters:

- light conditions on the sea floor;
- sedimentation rate;
- microphytobenthos species;
- microphytobenthos primary production;
- meiofauna species;
- nutrients in interstitial water;
- sediment metabolism expressed through respiration.



**Sampling in the seagrass meadow of *Posidonia oceanica*. (Photo: J. Forte)**

**Vzorčevanje na travniku pozidonije. (Foto: J. Forte)**

### Marking the lower limit of the meadow

In order to be able to monitor the development of the meadow, 6 marks were placed at its lower limit, while 4 of them were used to mark the outer border of a single patch. In accordance with the methodology used in GIS Posidonie, photographs of the situation were taken in order to enable a follow-up of the evolution of the meadow and the eventual changes in its lower limits.

### Installing signposts

Owing to the fact that the meadow is located in urban area with somewhat intense recreational use, especially in summer, the signposts constitute an important tool in spreading the awareness of the importance of the meadow and its conservation. Taking into account the specificity of the area, two signposts, explaining the main characteristics as well as importance of *P. oceanica* and the conservation measures adopted, were foreseen.

### Public awareness raising

As mentioned above, all the activities were used as a tool to raise public awareness concerning the importance of the meadow and the need for its conservation. However, a special event was organised in order to inform the public on the activities carried out within the framework of the project. This event included a press conference, a field trip, lectures by Gerard Pergent and Christine Pergent-Martini from the University of Corte, and exhibition dedicated to *P. oceanica* meadows, their importance and role.

### Future activities

Two main sets of activities are foreseen and needed in the near future. The first concerns the meadow's legal protection. The activities include above all establishment of a protected area and definition of its management. The implementation of this activities depends primarily on the Ministry of Environment, Physical Planning and Energy and to a lesser extent on the Institute of the Republic of Slovenia for Nature Conservation. These activities are a must, as the area is also a proposed Natura 2000 site.

The second set of activities concerns the monitoring of the area – development of the meadow and other habitat types, checking out the species list, ecological parameters, etc. The monitoring is to be performed in concordance with the methodology used by GIS Posidonie. This would allow a suitable comparison with the results obtained in other parts of the Mediterranean.

At the end of this short report on the activities carried out with the aim to provide for efficient, long-term con-

servation of the only *P. oceanica* meadow in the Slovene sea and in the entire Gulf of Trieste, I would like to express my cordial thanks to the International Cooperation for Environment and Development of the Principality of Monaco, the Regional Activity Centre for Specially Protected Areas (RAC/SPA) of the Barcelona Convention, and to the MAP Coordination Unit in Athens for their financial and technical support.



*Posidonia oceanica* (Photo / Foto: T. Makovec)

Robert Turk

### QUANTO VALE LA COSTA DI MUGGIA? LA PAROLA AGLI ESPERTI

Il 25 Gennaio 2003 si è tenuto a Muggia un incontro pubblico dal provocatorio titolo "Quanto vale la costa di Muggia? La parola agli esperti". L'iniziativa ha visto la partecipazione di numerosi esperti, i quali hanno messo in luce le caratteristiche peculiari del litorale muggesano sotto diversi punti di vista. La folta schiera di associazioni promotrici, tra queste l'Associazione Micologica Bresadola, il CAI, il Circolo Istria, la Fameia Muiesana, Italia Nostra, Lega Ambiente, la Società di Studi Nettuno, Il Comitato SOS Muggia e il WWF, hanno infatti sentito la necessità di conoscere e far conoscere il litorale muggesano in vista dei progetti di interrimento e di creazione di nuove strutture portuali turistiche previsti nel PRG del Comune di Muggia.

I primi due interventi hanno definito l'area dal punto di vista storico-archeologico. In particolare, il dott. Franco Stener della Fameia Muiesana ha illustrato i confini geografici e storici del territorio muggesano ed ha delineato i limiti dello sviluppo turistico ed economico del territorio costiero in un intervento dal titolo "Limiti e prospettive della penisola muggesana".

Ha fatto quindi seguito l'intervento della dott.ssa Rita

Auriemma, archeologa e ricercatrice presso il Dipartimento di Scienze dell'Antichità dell'Università di Trieste. Il suo contributo, dal titolo "Evidenze archeologiche sommerse lungo la costa muggesana", ha posto l'attenzione sui numerosi resti romani sparsi lungo la riviera muggesana ed ha inoltre posto l'attenzione sulla vulnerabilità delle antiche strutture sommerse sia per effetto distruttivo del moto ondoso sia per l'attività antropica. La dott.ssa Auriemma ha auspicato una nuova prospettiva di ricerca, per restituire al paesaggio costiero l'integrità e la comune identità; prospettive queste che animano il progetto di ricerca sui siti costieri dell'Alto Adriatico, presentato dal Dipartimento di Scienze dell'Antichità in collaborazione con il Museo del Mare di Pirano nell'ambito del progetto comunitario INTERREG IIIA Italia-Slovenia.

Il dott. Stefano Furlani, geomorfologo costiero presso la Società di Studi Nettuno, in "Aspetti geologici e geomorfologici della Valle di S. Bartolomeo, tra Punta Grossa e Punta Sottile", ha focalizzato l'attenzione sulle caratteristiche geologiche e geomorfologiche delle coste della Valle di S. Bartolomeo, delle falesie e della piattaforma costiera che si sviluppa tra Punta Sottile e Punta Grossa. Il dott. Furlani suggerisce peraltro che *"la particolare valenza di tale struttura come "geosito" costiero unico nell'Adriatico potrebbe fornire un valido input alla fruizione eco-turistica sia locale che internazionale ... quindi l'utilizzo della piattaforma come polo di attrazione per attività sostenibili potrebbe essere la soluzione per impiegare integralmente tutte le ricchezze, archeologiche e ambientali, che hanno come substrato gli affioramenti sommersi"*.

Il dott. Michele Codogno, ecologo vegetale e ricercatore presso il Dipartimento di biologia dell'Università di Trieste, ha messo in luce le caratteristiche vegetazionali della zona di Punta Olmi, in un intervento dal titolo "La vegetazione forestale tra Punta Ronco e Punta Sottile". La conclusione, a cui giunge il dott. Codogno, è la possibilità di sviluppare un atteggiamento attivo di conservazione in modo da preservare il territorio dal degrado, magari puntando verso coltivazioni specializzate di elevata qualità e proponendo un'azione mirata al governo naturalistico del bosco e alla cura della prateria per mantenere un elevato grado di biodiversità.

Nell'intervento successivo, "I fondali tra conservazione e sviluppo sostenibile", il dott. Roberto Odorico, biologo presso la Riserva marina di Miramare, ha posto l'accento sullo sviluppo sostenibile dell'area, evidenziando che in ambito marino-costiero l'insieme delle naturalità presenti nell'area potrebbero costituire un efficace richiamo turistico e, opportunamente trattate in termini ecologici, potrebbero accentuare l'efficacia degli interventi di recupero e focalizzare le onerose operazioni di monitoraggio non fini a se stesse, ma solo dove sussista una reale conflittualità tra attività umane e modifica dell'ambiente.



**Prateria di *Cymodocea nodosa* presso Punta Sottile, Muggia. (Photo: R. Pertoldi)**

**Morski travnik kolenčaste cimodoceje pri Tenkem rtiču (Punta Sottile) blizu Milj (Muggia). (Foto: R. Pertoldi)**

Il prof. Giuliano Orel, professore associato presso il Dipartimento di biologia dell'Università di Trieste, nell'esposizione delle caratteristiche dei fondali lungo la costa da Muggia a San Bartolomeo, ha evidenziato l'enorme importanza che quest'area svolge nella captazione del novellame di diverse specie di molluschi da avviare a coltura a fondale o in sospensione. I caratteri di originalità ed altre condizioni favorevoli di tutto il litorale tra Muggia e Punta Sottile, ma anche da questa a S. Bartolomeo, sono stati "recepiti nel progetto della Riserva Marina a cavallo del confine", anche questo inserito nell'ambito del progetto INTERREG IIIA.

La soluzione di continuità paesaggistica, geologica e naturalistica che investe tutto il litorale è stata ribadita anche dal prof. Lovrenc Lipej, biologo marino del Marine Biology Station, National Institute of Biology di Pirano. Il prof. Lipej ha illustrato gli organismi marini che popolano la Riserva Naturale di Strugnano, il Monumento Naturale di Punta Madonna ed il Monumento Naturale di Punta Grossa ed ha posto l'attenzione su queste zone protette come "efficiente strumento per la protezione della biodiversità marina".

L'ultimo intervento ha analizzato i vantaggi che i bagni in mare apportano all'organismo, grazie all'esperienza della naturopata Mariella Colarich del Comitato SOS Muggia. Nell'intervento "Il mare e il nostro benessere" la Colarich ha analizzato in particolare gli elementi che interagiscono sul corpo e sull'organismo: il mare, l'aria, il sole, l'aria il nuoto ed il massaggio.

La fascia costiera muggesana ha quindi evidenziato una sostanziale continuità paesaggistica, grazie alla presenza di una serie di elementi comuni di tipo geomorfologico, che comprendono i vasti affioramenti rocciosi subacquei della piattaforma costiera intertidale e subtidale, biologico, grazie all'elevata biodiversità e arche-

ologico, per la presenza di interessanti strutture costiere romane. Sarà quindi necessario, in un futuro prossimo, cercare delle soluzioni di sviluppo dell'area che prevedano l'integrazione e la valorizzazione di tutti questi elementi nel quadro economico dell'area.

**Stefano Furlani**

LA FONDAZIONE CETACEA ONLUS



La Fondazione Cetacea ONLUS è un'organizzazione senza scopo di lucro, ufficialmente riconosciuta dalla Regione Emilia-Romagna con Decreto n. 233 del 2/VII/97, ed individuata quale Centro di Educazione Ambientale con Determinazione della D.G. Ambiente della medesima regione n. 9582 del 28/IX/98. Essa opera per lo studio e la conservazione dei cetacei e degli altri vertebrati marini, e più in generale, per la tutela del mare e delle sue risorse. Sin dal 1988 è attivamente impegnata nei settori della ricerca, della conservazione e dell'educazione ambientale avvalendosi del contributo di biologi, veterinari, naturalisti e volontari. Essa gestisce inoltre le attività didattiche e di ricerca del Delphinarium Riccione.

Sono scopi statuari della Fondazione Cetacea, tra gli altri: promuovere ed attuare studi e ricerche sui mammiferi ed altri animali marini, con particolare attenzione alle specie minacciate; attuare iniziative per il soccorso, la cura e la riabilitazione di animali marini in difficoltà; promuovere studi sui fattori e sulle cause che determinano lo spiaggiamento degli animali marini; promuovere ed attuare ricerche sui cetacei in ambienti controllati, finalizzate sia al miglioramento della qualità del loro mantenimento in acquario, sia allo studio e alla loro conservazione nell'ambiente naturale; promuovere studi e ricerche sugli ecosistemi marini e sugli ecosistemi fluviali e lacustri ad essi collegati, nonché sui fattori che possono alterare le condizioni di vita degli animali marini; attuare iniziative per la diffusione delle conoscenze sui cetacei, sugli altri animali marini e sul loro ambiente, nonché per l'educazione ambientale in

genere; attuare iniziative per la ricerca, la conservazione e la diffusione delle tradizioni popolari legate al mare ed ai suoi abitanti; prestare consulenza ed assistenza ad enti pubblici e privati nell'ambito delle attività sopra elencate; fornire consulenze scientifiche e didattiche; organizzare e gestire corsi di educazione ambientale e corsi di formazione e di aggiornamento per educatori, insegnanti, ricercatori ed operatori.

La Fondazione Cetacea organizza mostre, promuove percorsi didattici per le istituzioni scolastiche, realizza progetti e pannelli educativi, documentari, pubblicazioni divulgative e manifestazioni mirate a coinvolgere interlocutori di età ed interessi differenti; cura per i delfinari di Riccione e Cattolica gli aspetti didattici ed educativi. Contribuisce inoltre a diffondere i risultati delle ricerche scientifiche a cui collabora concretamente e, insieme alle maggiori associazioni ambientaliste, conduce campagne con l'obiettivo di creare oppure modificare quelle normative che mirano alla tutela dell'ambiente marino.

La conoscenza scientifica degli animali marini, obiettivo primario della ricerca, è anche indispensabile per la loro conservazione. La Fondazione Cetacea collabora con numerosi istituti ed università per studi su:

- accumulo di inquinanti – metalli pesanti, PCB – in cetacei, squali e tartarughe (con l'Università di Siena, l'Università di Ancona e con il Centro Studi Ambientali di Rimini);
- utilizzo del biosonar in *Tursiops truncatus*, sia in cattività, sia in mare (con il CNR-IRPeM di Ancona);
- comportamento e variazione di parametri biologici nelle ultime fasi della gravidanza in *Tursiops truncatus* (con i delfinari di Cattolica, Genova e del Parco Asterix e con l'Università di Milano);
- variazione del tasso di progesterone, ormoni tiroidei e cortisolo nel sangue in *Tursiops truncatus* (con l'Università di Perugia);
- effetti tossici del mercurio sui cetacei odontoceti (con le Università di Pisa e di Siena);
- predazione su pesci ossei e presenza di parassiti nell'apparato gastro-intestinale di tartarughe comuni *Caretta caretta* (con le Università di Perugia, Ancona, Milano, Varese, Zagabria, Valencia);
- marcatura di tartarughe con radio-trasmettitori satellitari (con CTS ambiente e CNR Firenze);
- determinazione dell'età su sezioni ossee di tartarughe (con l'Università di Ancona);
- comportamento alimentare di alcuni squali (*Squalus acanthias*, *Mustelus* sp., *Scyliorhinus canicula*) nel medio Adriatico (con l'Università di Ancona);
- presenza di neonati di squalo grigio (*Carcharhinus plumbeus*) in alto Adriatico;
- comportamento alimentare di cetacei odontoceti (con l'Università di Ancona).

Oltre a proseguire tutte le ricerche citate, la Fondazione Cetacea ha in corso di svolgimento i seguenti progetti:



- marcatura di squali elefante *Cetorhinus maximus* tramite tags satellitari (con l'ICRAM di Roma, l'ARPA di Cesenatico, le stazioni navali della Guardia di Finanza e le Capitanerie di Porto);

- marcatura e studi dell'accrescimento degli squali neonati (*Prionace glauca*) nella *nursery area* dell'alto Adriatico (con FarVest e Oceanomare di Ravenna);

- censimento delle specie di squali oggetto di pesca professionale, e analisi del contenuto gastrico (con CTS di Lampedusa);

- analisi sulla posizione delle tartarughe nella catena alimentare utilizzando isotopi radioattivi del carbonio e dell'azoto (con CNR Firenze, Università di Camerino e Università di Bologna);

- valutazione dell'atteggiamento di insegnanti e alunni a percorsi didattici tradizionali e spettacolarizzati (con l'Università di Bologna);

- studio del comportamento di tursiopi in ambiente controllato, nella formazione di un nuovo gruppo sociale;

- analisi dell'età di tursiopi tramite densità ossea (con l'Università di Padova);

- analisi parassitologiche in cetacei (con le Università di Padova e di Torino);

- studio e monitoraggio dei cetacei presenti nel mare antistante il Monte Conero;

- monitoraggio delle spiagge di deposizione di tartarughe nella parte sud-occidentale di Rodi;

- analisi parassitologiche, anatomiche e di inquinanti in pesce luna (*Mola mola*);

- progetti di ricerca e conservazione di cavallucci marini (*Hippocampus* sp.) in Mediterraneo;

- progetti di ricerca e conservazione di fauna e flora terrestri (pellicano riccio, lontra, rana di Lataste, nutria, arvicola, biscia dal collare);

- ricerche di ecosistemi terrestri (aree umide del Delta, pinete litoranee).

La Fondazione Cetacea, nell'ambito del Progetto Spiaggiamenti, ha collaborato con il Centro Studi Cetacei, di cui è stata referente per le regioni Emilia-Romagna e Marche. Questo progetto ha come scopo sia il recupero delle carcasse dei Cetacei spiaggiati lungo le coste italiane, sia interventi di soccorso sugli esemplari ancora in vita e, al termine di ogni anno, la redazione di un dettagliato rendiconto. L'interesse scientifico della Fondazione Cetacea si è concentrato soprattutto sul mare Adriatico, dove abbiamo documentato la presenza in epoche storiche e recenti di pseudorca, capodoglio, delfino comune e il primo (e tuttora unico) avvistamento di megattera.

Dal 1988 al 2002 sono stati raccolti reperti di grande rilevanza scientifica. Provenienti da 87 carcasse, sono oggi in parte conservati e catalogati in una importante collezione. Notevole interesse scientifico rivestono i reperti di specie rare come il delfino comune, il grampo e la balenottera comune.

Interventi su cetacei vivi. La Fondazione è intervenuta in più di 30 interventi su cetacei in difficoltà su diverse specie, su tutto il territorio italiano e/o ospedalizzati nella sua struttura di pronto soccorso e ospedalizzazione.

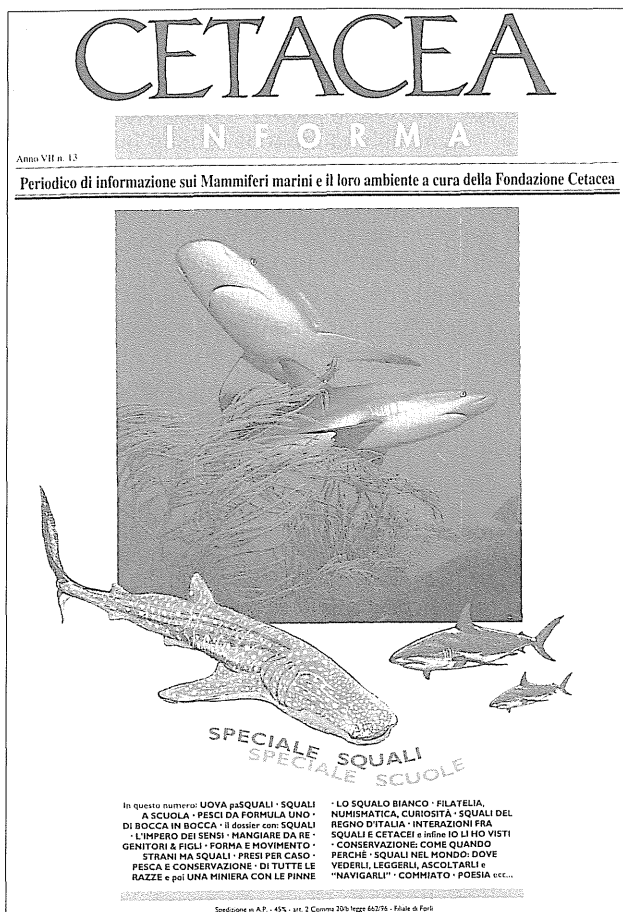
Le tartarughe sono a rischio di conservazione sia perché l'urbanizzazione costiera sta limitando le aree nelle quali vengono deposte le uova sia perché moltissimi esemplari vengono accidentalmente uccisi durante le attività legate alla pesca. La Fondazione Cetacea è un punto di riferimento per l'area costiera dell'alto Adriatico: vanta una lunga esperienza acquisita in 15 anni di attività presso le vasche ospedale a suo tempo allestite presso il Delphinarium Riccione e presso la Delphinursery Cattolica e dispone di una rete di collaboratori e volontari.

Durante questi 15 anni sono state recuperate circa 500 tartarughe (vive o morte). Oltre 150 esemplari di *Caretta caretta* sono stati rilasciati, previa marcatura, dopo un periodo di degenza.

La popolazione di squali dell'Adriatico è fra gli obiettivi delle ricerche scientifiche compiute dalla Fondazione Cetacea; ricordiamo ad esempio l'individuazione di una possibile nursery per lo squalo grigio (*Carcharhinus plumbeus*), il progetto di marcatura di squali elefante (*Cetorhinus maximus*) tramite tags satellitari, gli studi sul comportamento alimentare di alcuni squali (*Squalus acanthias*, *Mustelus* sp., *Scyliorhinus canicula*). Tali attività proseguono e si ampliano, grazie a nuove collaborazioni e linee di ricerca. La sensibilizzazione e la divulgazione sono altri obiettivi di questo progetto, sui quali la Fondazione si molto impegnata: dalla mostra "Squali! Dalla parte dei cattivi" esposta al Delphinarium Riccione, all'Oasi Blu del WWF di Gianola (LT), al Delfinario di Fasano (BR), all'Acquario di Milano, alla petizione, con la raccolta di 10.000 firme, per la protezione della verdesca e dello squalo volpe nell'importantissima area nursery dell'alto Adriatico, alla realizzazione di un numero monografico di Cetacea Informa (il 13), alla collaborazione nell'organizzazione del "7<sup>th</sup> European Elasmobranch Association Meeting", convegno europeo sugli squali che si tiene annualmente, alla campagna 2003 anti finning con "Uno Squalo Per Amico" e altri partner.

Il progetto "Onde dal Mare" è stato istituito nel 1993 dalla Fondazione Cetacea di Riccione. "Onde dal Mare" raccoglie segnalazioni per il monitoraggio dello stato dell'ambiente marino attraverso una rete informativa che si avvale del contributo della Guardia di Finanza, delle Capitanerie di Porto e di pescatori e diportisti. Tali segnalazioni riguardano sia avvistamenti di cetacei, tartarughe ed elasmobranchi, che l'eventuale presenza di fenomeni potenzialmente pericolosi per l'ambiente e la navigazione. La Coop. M.A.R.E. di Cattolica ha in seguito aderito al progetto in qualità di referente per il settore danni ambientali.





Il progetto ha ottenuto il patrocinio del Ministero dell'Ambiente. Il centralino è raggiungibile via radio sul canale VHF 74 (156.725 MHz) e telefonicamente al numero 0541-691557.

**Marco Affronte**

#### MORIGENOS – DRUŠTVO ZA RAZISKOVANJE IN ZAŠČITO MORSKIH SESALCEV

Morigenos – društvo za raziskovanje in zaščito morskih sesalcev je neprofitna nevladna organizacija, ki se posveča zlasti morskim sesalcem in ohranitvi morskega okolja. Osredotočeni smo predvsem na kite in delfine v Jadranskem morju, s poudarkom na velikih pliskavkah (*Tursiops truncatus*) v Tržaškem zalivu.

Društvo smo ustanovili leta 2001. Sodelujemo v različnih mednarodnih projektih, vendar je naš glavni projekt vezan na aktivnosti raziskovanja in ohranitve delfinov v Tržaškem zalivu. Tako ali drugače sodelujemo (zbiranje in izmenjava podatkov, izkušenj in mnenj, izmenjava literature, javni nastopi) z mnogimi organizacijami doma in v tujini, kot so Morska biološka postaja Piran, Akvarij Piran, Srednja pomorska šola

Portorož, Društvo za dobrobit živali, Blue World Institute of Marine Research and Conservation, Cetacean Research Group (University of Athens), ASMS – Swiss Marine Mammal Protection, Riserva naturale marina di Miramare, Tethys Research Institute, Whale and Dolphin Conservation Society, Oceanomare in druge. Redno se udeležujemo mednarodnih konferenc.

Poleg spremljanja oz. opazovanja delfinov se ukvarjamo tudi z ozaveščanjem, izobraževanjem in informiranjem javnosti, predvsem prek tematskih predavanj s projekcijami diapozitivov, z razstavami, delavnicami, objavami člankov v časopisih in revijah in s sodelovanjem na radijskih in televizijskih oddajah.

Poleti organiziramo raziskovalne tabore, v katerih se predvsem mladi lahko uvajajo v spoznavanje metod opazovanja delfinov. Uresničujemo tudi projekt "Posvojite delfina!", ki je v prvi vrsti projekt za informiranje in ozaveščanje javnosti, hkrati pa z njim zbiramo sredstva za naše delovanje.

Društvo se je poleti 2002 lotilo prvih predhodnih opazovanj v slovenskem morju, v začetku leta 2003 pa smo začeli aktivno in redno fotoidentifikacijo velikih pliskavk v naših vodah. Glavni del raziskovanj je metoda, imenovana foto-identifikacija. Vsak delfin ima na hrbtni plavuti določene značilnosti, kot so brazgotine, pege, zareze, kako nenavadno obliko plavuti in druge posebnosti, po katerih ga ločimo od drugih pripadnikov v skupini. Do danes smo na podlagi teh "naravnih oznak" identificirali 23 delfinov in vsakemu dali tudi svoje ime. Med njimi je tudi nekaj samic z mladički; ena izmed njih ga je skotila letos maja. Potrebna bodo nadaljnja opazovanja in novi podatki, saj želimo s fotoidentifikacijo oceniti velikost populacije, ki živi pri nas. Populacija velikih pliskavk v slovenskem morju je namreč stalna, kar pomeni, da se delfini tu pojavljajo ves čas in niso le občasni obiskovalci naših voda. Opazovati želimo tudi vedenje delfinov na določenih območjih, medsebojne odnose med posameznimi živalmi ter vpliv človeških aktivnosti. Poleg tega načrtujemo izdatno ozaveščanje javnosti, in sicer z namenom, da opozorimo ljudi na ogroženost delfinov in potrebo po trajnostni (iz)rabi našega morja.

V društvu je kakih 20 članov. Znanje in izkušnje smo si nabirali predvsem v projektih raziskovalnih inštitutov, kakršni so Tethys iz Lošinja (Adriatic Dolphin Project), Blue World Institute of Marine Research and Conservation (Adriatic Dolphin Project), Cetacean Research Group, University of Athens (Striped Dolphin Project), Atlantic Whale Foundation, Cardigan Bay Wildlife Research and Conservation Centre.

Članstvo v društvu je prostovoljno in namenjeno vsem, ki želijo prispevati k raziskovanju in zavarovanju kitov in delfinov v Jadranskem morju. Sestava društva je zelo pestra. Poleg študentov biologije, veterine in psihologije so tu diplomirani biologi in profesorji biologije, magistri veterine, dijaki ter drugi.



**Progasti delfin** (*Stenella coeruleoalba*). (Foto: T. Genov).  
**Striped dolphin** (*Stenella coeruleoalba*). (Photo T. Genov)

Zahvaljujemo se vsem podjetjem, ustanovam in organizacijam, ki so nam pomagala pri naši dejavnosti. To so predvsem Srednja pomorska šola Portorož, Akvarij Piran, Morska biološka postaja Nacionalnega inštituta za biologijo Piran, Služba za varstvo obalnega morja, in drugi.

**Tilen Genov**

#### MEDNARODNA KONFERENCA O EPIKRASU (Interdisciplinary Workshop on Epikarst)

Med 1. in 4. oktobrom 2003 je bila v Zahodni Virginiji (ZDA), v kraju Shepherdstown, mednarodna konferenca o epikrasu. Organizirala jo je ameriška nevladna naravovarstvena organizacija Karst Waters Institute (KWI), katere cilj je izboljšati osnovno razumevanje kraških vodonosnih sistemov. Organizacija skuša s pomočjo znanstvene stroke širiti in poglobljati znanje o krasoslovju, kar ji uspeva tudi z organiziranjem mednarodnih srečanj.

Tokratna konferenca je potekala v kongresnem centru hotela Clarion Inn. Mednarodni del konference je potekal v sklopu rednih srečanj krasoslovcev, z aktivno udeležbo svetovno znanih strokovnjakov, kot so dr. D. Ford, dr. A. Palmer, dr. J. Mylroie in dr. P. Williams. Sicer pa tudi mednarodni del udeležbe ni bil zanemarljiv. Konferenca se je udeležilo kakih 75 raziskovalcev iz približno 15 držav. Še posebej močna je bila ekipa iz Slovenije, s predstavniki biologov, hidrogeologinje in fizika. Delo je potekalo v obliki strokovnih tematskih predavanj, posterjev, razprav oziroma okroglih miz in delovnih sestankov. S pozdravnim nagovorom dr. D. Culverja se je konferenca tudi uradno začela.

Jedro srečanja je sestavljalo 18 vabljenih predavanj, v katerih so predavatelji pregledno predstavili epikras. Skoraj vsi predavatelji so med vodilnimi raziskovalci na svojem področju. V konceptualnem modelu kraškega vodonosnega sistema so locirali plast epikrasa, opisali njegove funkcije in značilnosti. V svojih predavanjih so podali različice definicije epikrasa, predstavili rezultate geokemijskih in hidroloških raziskav epikrasa, raziskave o njegovem razvoju in hidrodinamični funkciji epikraške cone ter predstavili epikras vsega sveta. Trije slovenski raziskovalci (dr. B. Sket, dr. A. Brancelj in dr. T. Pipan) smo skupaj z dvema ameriškima biospeleologoma (dr. D. Culver in dr. D. Fong) predstavili celovit pregled bioloških raziskav epikrasa ter najnovejša odkritja o epikraški favni Slovenije ter načine in metode vzorčenja favne, ki poseljuje epikras.

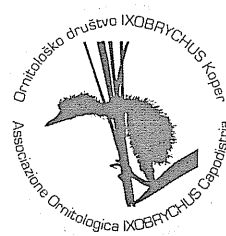
Udeleženci simpozija smo si v enem dopoldnevu ogledali kraški teren z lepo vidnim in izpostavljenim epikrasom. Udeležence je terensko delo še dodatno navdušilo in spodbudilo k številnim zanimivim razpravam.

Simpozij je bil eno redkih srečanj, kjer so bili med vabljenimi predavatelji enakovredno zastopani tako mladi kot starejši, že uveljavljeni raziskovalci. Predstavljeni referati bodo objavljeni v zborniku simpozija, ki ga izdaja KWI.

Glede na veliko število udeležencev iz različnih držav in njihovih prispevkov je bila tematika simpozija primerno raznolika in kompleksna. Osnovni namen in cilj simpozija je bil srečanje in povezovanje vseh ljudi, ki se ukvarjajo s krasoslovjem v širšem in z epikrasom v ožjem pomenu besede, predstaviti izsledke raziskav epikrasa ter prispevati k hitrejšemu in učinkovitejšemu interdisciplinarnemu komuniciranju.

**Tanja Pipan**

#### DVAJSET LET ORNITOLOŠKEGA DRUŠTVA IXOBRYCHUS IZ KOPRA



Dvajset let je že tega, odkar se je skupina koprskih ornitoloških zanesenjakov, ki so vsak zase raziskovali pestrost ptic na obalnih mokriščih Slovenske Istre, domislila, da bi se organizirala v strokovno društvo. Čeprav je na trenutke kazalo, da bo ornitologom v zadnjih

letih pošla sapa, je društvo prebrodilo krizo in uresničilo številne zamisli.

V zvezi s konkretnim uresničevanjem Ramsarske konvencije v Sloveniji so izdelali dve poročili za Nacionalni komite – IOC (International Oceanographic Committee): poročilo o inventarizaciji ptic – gnezdilk ter poročilo o prezimovanju in preletu ptic na območju Sečoveljskih solin.

V sodelovanju s podjetjem Soline so člani društva leta 1997 opravili študijo z naslovom *Možnosti sonaravnega gospodarjenja s Sečoveljskimi solinami* in pripravili obsežno gradivo o ornitofavni prijaznem trajnostnem gospodarjenju s Sečoveljskimi solinami. Morda so bile ravno izkušnje te študije odločilne, da jim je v naslednjih dveh letih uspelo skupaj z Znanstveno-raziskovalnim središčem Republike Slovenije v Kopru pridobiti projekt "*Sečoveljske soline – načrt upravljanja*", ki je navedel strokovne argumente za sestavo upravljalškega načrta. Leta 1999 je Društvo za opazovanje in preučevanje ptic Slovenije podelilo trem članom društva nagrado Zlati legat, s katerim nagradijo najboljše delo s področja ornitologije v Sloveniji.

Da je društvo prišlo v zrelo fazo delovanja, kažejo uspešno izpeljani evropski projekti. V letih 2000 in 2001 je članom Ornitološkega društva uspelo izpeljati projekt PHARE (SPF) z naslovom *Možnosti izobraževalnih aktivnosti na zaščitanih območjih v luči trajnostnega razvoja* (društvo je bilo nosilec projekta). Projekt je obravnaval zavarovana območja na obrežju Tržaškega zaliva in v morju na obeh straneh meje. Člani društva so izdelali lični katalog izobraževalnih vsebin na zaščitanih območjih od reke Dragonje do izliva Soče na italijanski strani. Še bolj odmeven je bil s tega vidika projekt *All about salt – ALAS* (Ecos Ouverture – projekt Evropske skupnosti, 2000-2002), ki je potekal na območju Krajinskega parka Sečoveljskih solin in obravnaval revitalizacijo tradicionalnega načina pridobivanja soli v zavarovanem območju. V projektu so sodelovali evropski partnerji Lesvos (Grčija), Figuera da Foz (Portugalska), Pomorie (Bolgarija) in Piran (Slovenija). V slovenskem delu projekta so vključeni Občina Piran (kot glavni partner) ter Medobčinski zavod za varstvo naravne in kulturne dediščine Piran, Pomorski Muzej "Sergej Mašera" in društvo.

V projektu je društvo opravljalo naloge v zvezi s promocijo Krajinskega parka Sečoveljske soline (posterji, zloženke, razstava) in izdelavo umetnih gnezdišč za nekatere v slovenskem in sredozemskem merilu redke vrste ptic, ki v Sečoveljskih solinah gnezdiijo. Izdelali so poster in zgibanko o naravni dediščini Sečoveljskih solin ter razstavo na isto temo, ki je bila v Piranu in Kopru dobro obiskana. Sodelovali so na vseh mednarodnih konferencah ALAS. Organizirali so tudi okroglo mizo o Sečoveljskih solinah, in sicer dan pred svetovnim dnem mokrišč v prostorih občine Piran. Udeležili so se številni predstavniki, med drugimi tudi s strani ustreznih državnih ministrstev.



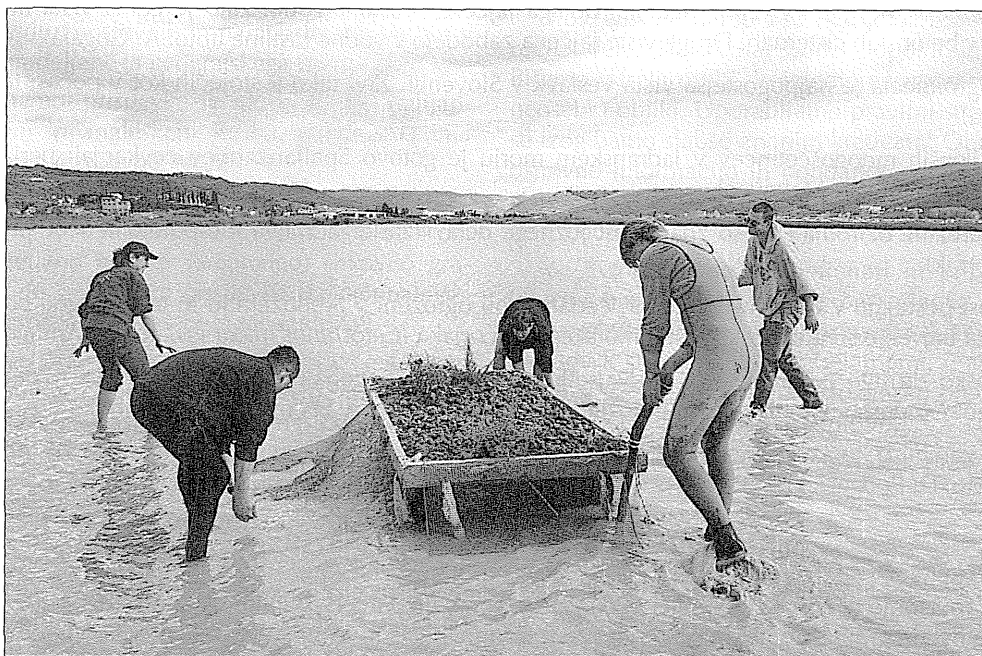
Osnovne dejavnosti monitoringa gnezdečih ptic v Sečoveljskih solinah in štetja prezimujočih ptic na slovenskih obrežnih mokriščih so dopolnile nekatere druge, medijsko odmevnejše dejavnosti, kot npr. postavitve gnezdilnih platform za čigre. Na podlagi skoraj dvajsetletnega spremljanja solinske ornitofavne se je namreč izkazalo, da so zgodnje poletne ujme katastrofalne za mnoge vrste solinskih gnezdilk. Vse prevečkrat se je namreč dogajalo, da so z dežjem izdatne ujme spirale jajca iz gnezd ali poplavlale celotne nasipe z gnezdi. Člani društva so s pomočjo finančnih sredstev v okviru projekta ALAS v letu 2002 postavili 8 plavajočih gnezdilnih platform. Številni člani so zavihali rokave in v nič kaj prijaznem vremenu prepeljali, prenesli in zvlekli ter pričvrstili platforme na sredo solinskega bazena. Gnezdilne platforme so se izkazale kot učinkovito sredstvo za preprečevanje posledic poletnih ujm, saj so čigre novo domovanje takoj naselile in pričele z gnezdenjem.

Aktivno večletno sodelovanje s podjetjem Soline d.o.o. in dogovarjanje z njimi o možnostih za sonaravno gospodarjenje s Sečoveljskimi solinami je v zadnjem letu doseglo svoj višek, zato tudi ni čudno, da se je Ornitološko društvo Ixobrychus znašlo v vlogi pridruženega partnerja podjetju Soline d.o.o. Skupna prijava na razpis za Koncesijo za upravljanje Krajinskega parka Sečoveljske soline je obrodila sadove. Danes imajo Sečoveljske soline kot najpomembnejša slovenska ornitološka lokaliteta upravljalca, s tem pa je smiselno pričakovati, da so Sečoveljske soline naposled postale zaščitene tudi v praksi. S tem je gotovo zadoščeno tudi enemu izmed začetnih temeljnih ciljev društva, učinkoviti zaščiti (za zdaj še) edinega ramsarskega mokrišča v Sloveniji.

Vse pa ni šlo vedno kot po maslu. Še vedno se društvo otepa s problemi rekrutiranja mladih ornitologov in drugih navdušencev. Le upati je, da mu bo uspelo privabiti nove člane in simpatizerje, saj je treba tudi v prihodnje spremljati dogajanje v Krajinskem parku in opozarjati na pomanjkljivosti ali na napake pa tudi na

različne oblike pritiskov. Še do nedavnega so bile zelo žive pobude po širjenju letališke steze v Krajinski park, kar več kot nazorno kaže, da so apetiti nekaterih navzlic z zakonom podprtemu statusu solin še vedno nepotešeni.

**Lovrenc Lipej**



*Postavljanje gnezdilnih platform za čigre. (Foto: A. Šalamun)*  
*The settlement of nesting platforms for terns (Photo: A. Šalamun)*

## KAZALO K SLIKAM NA OVITKU

Slika na naslovnici: Četverica progastih delfinov (*Stenella coreuleoalba*) med sproščenim plavanjem nekje v Jonskem morju. Progasti delfini se lahko pojavljajo v skupinah z nekaj osebki pa vse do velikih skupin, ki lahko štejejo nekaj sto članov (foto: T. Genov).

Sl. 1: Progasti delfin (*Stenella coreuleoalba*) je poleg velike pliskavke danes najpogostejša delfinja vrsta v Jadranu in Sredozemlju (foto: T. Genov).

Sl. 2: Lisasta hrbtnoplovka (*Notonecta maculata*) odlaga jajčeca prosto v vodo, zato je edina vrsta hrbtnoplovke, ki lahko živi tudi v betonskih cisternah. Druge vrste jajčeca zabodejo v vodne rastline (foto: A. Gogala).

Sl. 3: *Sigara nigrolineata* je najpogostejša vrsta veslavk v Sloveniji. Živi tako v stoječih kot v počasi tekočih vodah (foto: A. Gogala).

Sl. 4: Eden najlepših mnogoščetincev v Jadranskem morju je gotovo Spallanzanijev cevkar ali perjaničar (*Spirographis spallanzani*) (foto: T. Makovec).

Sl. 5: Flišnate brežine oziroma klifi so značilnost južnega dela Tržaškega zaliva, od polotoka Seče pa vse do Trsta (foto: D. Podgornik).

Sl. 6: Morski psi postajajo v zadnjih desetletjih čedalje bolj ogroženi v Sredozemlju in tudi drugod po svetu. To še posebej velja za največjo sredozemsko vrsto, morskega psa orjaka (*Cetorhinus maximus*) (foto: B. Šuligoj).

Sl. 7: Ornitološko društvo Ixobrychus je v dvajsetletni zgodovini izpeljalo marsikateri projekt. Eden najbolj odmevnih je bil gotovo postavitve plavajočih gnezdilnih platform za čigre v Sečoveljskih solinah (foto: A. Šalamun).

Sl. 8: Najbolj zanimiva točka v Naravnem spomeniku Debeli rtič je njegov skrajni rt, znan po geomorfoloških posebnostih (foto: D. Podgornik).

## INDEX TO PICTURES ON THE COVER

Front cover: A foursome of striped dolphins (*Stenella coreuleoalba*) freely swimming somewhere in the Ionian Sea. These dolphins live in groups numbering from just a few individuals to as many as few hundred members (photo: T. Genov).

Fig. 1: Apart from the bottlenosed dolphin, the striped dolphin (*Stenella coreuleoalba*) is today the most common dolphin species in the Adriatic and in the Mediterranean in general (photo: T. Genov).

Fig. 2: *Notonecta maculata* lays its eggs freely in water and is the only backswimmer species capable of living in concrete rainwater cisterns. Other species virtually stab their eggs into water plants (photo: A. Gogala).

Fig. 3: *Sigara nigrolineata* is the most common water boatman species in Slovenia. It lives in stagnant as well as slow flowing waters (photo: A. Gogala).

Fig. 4: One of the most attractive bristleworms in the Adriatic Sea is certainly the spiral tubeworm *Spirographis spallanzani* (photo: T. Makovec).

Fig. 5: These banks composed of flysch and their cliffs are particularly characteristic of the southern part of the Gulf of Trieste, from Seča Peninsula to Trieste (photo: D. Podgornik).

Fig. 6: In the last few decades, sharks have become increasingly endangered in the Mediterranean and elsewhere in the world. This holds particularly true of the largest Mediterranean species, the basking shark (*Cetorhinus maximus*) (photo: B. Šuligoj).

Fig. 7: In the 20 years of its existence, the ornithological association Ixobrychus has carried out numerous projects. One of the most important amongst them was its decision to set up floating breeding platforms for terns at Sečovlje Salina (photo: A. Šalamun).

Fig. 8: The most interesting feature of Debeli rtič Nature Monument is its extreme cape, known for its geomorphologic characteristics (photo: D. Podgornik).

## NAVODILA AVTORJEM

**1. ANNALES:** *Anali za istrske in mediteranske študije* - *Annali di Studi istriani e mediterranei* - *Annals for Istran and Mediterranean Studies* (do 5. številke: *Anali Koprskega primorja in bližnjih pokrajin* - *Annali del Litorale capodistriano e delle regioni vicine* - *Annals of the Koper Littoral and Neighbouring Regions*) je znanstvena in strokovna interdisciplinarna revija humanističnih, družboslovnih in naravoslovnih vsebin v podnaslovu opredeljenega geografskega območja.

2. Sprejemamo prispevke v slovenskem, italijanskem, hrvaškem in angleškem jeziku. Uredništvo ima pravico prispevke jezikovno lektorirati.

3. Prispevki naj obsegajo največ 24 enostransko tipkanih strani s po 30 vrsticami. Na levi pustite 3 do 4 cm širok rob. Zaželeno je tudi (originalno) slikovno gradivo, še posebno pa oddaja prispevka na računalniški disketi v programih za PC (osebne) računalnike.

4. Naslovna stran tipkopisa naj vsebuje naslov in podnaslov prispevka, ime in priimek avtorja, avtorjeve nazive in akademske naslove, ime in naslov institucije, kjer je zaposlen, oz. domači naslov vključno s pošto številko in morebitnim naslovom elektronske pošte.

Uredništvo razvršča prispevke v naslednje kategorije:

*Izvirni znanstveni članki* vsebujejo izvirne rezultate lastnih raziskav, ki še niso bili objavljeni. Dela pošlje uredništvo v recenzijo. Avtor se obvezuje, da prispevka ne bo objavil drugje.

*Pregledni članki* imajo značaj izvirnih del. To so natančni in kritični pregledi literature iz posameznih zanimivih strokovnih področij.

*Predhodno sporočilo* in *Gradiva* imajo ravno tako značaj izvirnih del.

*Strokovni članki* prikazujejo rezultate strokovnih raziskav. Tudi te prispevke uredništvo pošlje v recenzijo in avtor se obveže, da prispevka ne bo objavil drugje.

*Poročila* vsebujejo krajše znanstvene informacije o zaključenih raziskovanjih ali kratek opis strokovnih in znanstvenih knjig ali srečanj. Taki prispevki ne smejo presegati 5 strani.

*Mladinske raziskovalne naloge* morajo biti urejene kot strokovna dela.

*Komentarji* so namenjeni aktualnostim s strokovnega področja. Ne smejo presegati 2 strani.

*Obvestila* so namenjena društvenemu življenju. Obsegajo 1 stran.

5. Prispevek mora vsebovati **povzetek** in **izvleček**. Izvleček je krajši (cca. 10 vrstic) od povzetka (cca. 30 vrstic) in v nasprotju s povzetkom tudi ne vsebuje komentarjev in priporočil.

V **izvlečku** na kratko opišemo namen, metode dela in rezultate. Navedemo, čemu smo delo opravili ali na-

pisali dokument. Na že objavljeno gradivo se sklicujemo le, če je to glavni motiv dela. Na kratko opišemo metode in tehnike dela - kolikor je potrebno za razumevanje. Nove tehnike opišemo le, kjer se razlikujejo od že znanih. Če v delu ne opisujemo eksperimentalnega ali praktičnega dela, opišemo vire informacij. Rezultate in zaključke lahko združimo. Kar se da informativno navedemo le, kaj smo ugotovili oziroma odkrili.

*Povzetek* začnemo s stavkom, ki vsebuje glavno sporočilo dela. Stavki naj bodo popolni in ne predolgi. Pišemo v tretji osebi, le izjemoma uporabimo glagole v neosebni obliki. Uporabljamo pravilni strokovni jezik in se izogibamo slabše znanim kraticam. Ohraniti moramo osnovno informacijo in poudarke iz glavnega besedila. V povzetku ne sme biti ničesar, česar glavno besedilo ne vsebuje.

6. Avtorji so dolžni definirati in pripisati ustrezne **ključne besede** (pod izvlečkom) članka. Zaželeni so tudi **angleški (ali slovenski) prevodi** ključnih besed, podnapisov k slikovnemu in tabelarnemu gradivu. Priporočamo se še za angleški (ali slovenski) prevod povzetka, sicer bo za to poskrbelo uredništvo.

7. V besedilu se po možnosti držimo naslednjih poglavij:

1. Uvod.
2. Pregled dosedanjih objav.
3. Materiali in metode (Dokazni postopek).
4. Rezultati.
5. Razprava ali diskusija.
6. Zaključek (Sklepi).
7. Zahvala - če avtor želi.
8. Priloge - če je potrebno.
9. Literatura (Viri, Bibliografija).
10. Povzetek (Summary).
11. Izvleček.
12. Ključne besede (neobvezno).

8. Ločimo **vsebinske** in **bibliografske opombe**. Vsebinske opombe besedilo še podrobneje razlagajo ali pojasnjujejo, postavimo jih *pod črto*. Z bibliografsko opombo pa mislimo na citat - torej sklicevanje na točno določeni del besedila iz neke druge publikacije (navedemo tudi točno stran, kjer je citat objavljen) ali na publikacijo (članek) kot celoto (točne strani, kjer smo besedilo prevzeli, ne navajamo).

Bibliografsko opombo sestavljajo naslednji podatki:

Avtor, leto izida in - le če citiramo točno določeni del besedila - tudi navedba strani.

Celotni bibliografski podatki citiranih in uporabljenih virov so navedeni v poglavju *Literatura* (Viri, Bibliografija).

Primer citata med besedilom:

(Grafenauer, 1993, 11).

Primer navajanja vira kot celote, brez citiranja: (Grafenauer, 1993).



Popolni podatki o tem viru v poglavju Literatura pa se glasijo:

Grafenauer, B. (1993): Miti o "Istri" in resnica istrskega polotoka. V: Acta Histriae I. Koper, Zgodovinsko društvo za južno Primorsko, 9-52.

Če citiramo več del istega avtorja iz istega leta, poleg priimka in kratice imena napišemo še črke po abecednem vrstnem redu, tako da se viri med seboj razlikujejo. Primer:

(Grafenauer, 1993a); (Grafenauer, 1993b).

Bibliografska opomba je lahko tudi del vsebinske opombe in jo zapisujemo na enak način.

Posamezna dela ali navedbe virov v isti opombi ločimo s podpičjem. Primer:

(Gombač, 1996; Grafenauer, 1993b).

**9. Pri citiranju arhivskih virov** navedemo najprej arhiv, nato ime fonda ali zbirke in signaturo. V članku navajamo kratico arhivskega vira v oklepaju med besedilom. Kratico pa razložimo v poglavju o virih na koncu prispevka.

Primer navajanja arhivskega vira v oklepaju med besedilom: (PAK. RAG, 1)

Primer navajanja arhivskega vira v poglavju o virih: PAK. RAG - Pokrajinski arhiv Koper, Rodbinski arhiv Graviš, a. e. (arhivska enota) 1.

Podobno poskušamo ravnati pri uporabi časopisnih virov.

**10. Poglavje o literaturi in virih** je obvezno. Bibliografske podatke navajamo takole:

- Opis zaključene publikacije kot celote - knjige:

Avtor (leto izida): Naslov. Zbirka. Kraj, Založba.

Npr.:

**Verginella, M., Volk, A., Colja, K. (1995):** Ljudje v vojni. Druga svetovna vojna v Trstu in na Primorskem. Knjižnica Annales 9. Koper, Zgodovinsko društvo za južno Primorsko.

V zgornjem primeru, kjer je avtorjev več kot dva, je korekten tudi citat:

(Verginella et al., 1995)

Če navajamo določeni del iz zaključene publikacije, zgornjemu opisu dodamo še številke strani, od koder smo navedbo prevzeli.

- Opis prispevka v **zaključeni publikaciji** - npr. prispevka v zborniku:

Avtor (leto izida): Naslov prispevka. V: Avtor knjige: Naslov knjige. Izdaja. Kraj, Založba, strani od-do. Primer:

**Verginella, M. (1995):** Poraženi zmagovalci. Slovenska pričevanja o osvobodilnem gibanju na Tržaškem. V: Verginella, M. et al.: Ljudje v vojni. Druga svetovna vojna v Trstu in na Primorskem. Knjižnica Annales 9. Koper, Zgodovinsko društvo za južno Primorsko, 13-51.

- Opis članka v **reviji**:

Avtor (leto izida): Naslov članka. Naslov revije, številka. Kraj, Založba, strani od-do. Primer:

**Gombač, B. (1996):** Osvoboditev Trsta maja 1945. Annales 8/96. Koper, Zgodovinsko društvo za južno Primorsko - Znanstveno-raziskovalno središče Republike Slovenije Koper, 141-150.

- opis ustnega vira:

Informator (leto izporočila): Ime in priimek informatorja, leto rojstva, vloga, funkcija ali položaj. Način pričevanja. Oblika in kraj nahajanja zapisa. Primer:

**Baf, A. (1998):** Alojzije Baf, r. 1930, župnik v Vižinadi. Ustno izporočilo. Magnetofonski zapis pri avtorju.

- opis vira iz internetnih spletnih strani:

www. home page ustanove (leto-mesec izpisa): celoten naslov odstrani. Primer:

**www.zrs-kp.si (2000-07):**

<http://www.slo-istra.com/koper/zrs/zrs.html>

Članki so razvrščeni po abecednem redu priimkov avtorjev ter po letu izdaje, v primeru da gre za več citatov istega-istih avtorjev.

**11. Tiskarski znaki** za poudarke naj bodo:

podčrtano za **polkrepko**,

valovito podčrtano za *ležeče*.

Računalniški zapis naj vključuje ustrezne oznake za bold in *italics*.

**12. Kratice** v besedilu moramo razrešiti v oklepaju, ko se prvič pojavijo. Članku lahko dodamo tudi seznam uporabljenih kratic.

**13. Pri ocenah publikacij** navedemo v naslovu prispevka avtorja publikacije, naslov, kraj, založbo, leto izida in število strani (oziroma ustrezen opis iz točke 10).

**14. Prvi odtis prispevkov** uredništvo pošlje avtorjem v **korekturo**. Avtorji so dolžni popravljeno gradivo vrniti v treh (3) dneh. Besedilo popravljamo s korekturnimi znamenji, ki jih najdemo na koncu Slovenskega pravopisa (1962), Ljubljana, ali v: Slovenski pravopis 1. Pravila (1990). Ljubljana, SAZU-DZS, 13-14.

Širjenje obsega besedila ob korekturah ni dovoljeno. Druge korekture opravi uredništvo.

**15. Uredništvo** prosi avtorje, naj navodila vedno upoštevajo. Ob vseh nejasnostih je uredništvo na voljo za vsa pojasnila.

UREDNIŠTVO

## INSTRUCTIONS TO AUTHORS

1. **ANNALES: Annals for Istran and Mediterranean Studies - Anali za istrske in mediteranske študije** (up to No. 5: *Annals of the Koper Littoral and Neighbouring Regions - Anali Koprskega primorja in bližnjih pokrajin*) is a scientific and research interdisciplinary review covering the humanities, sociology and natural science in the area as stated in the review's subtitle.

2. Articles (papers) written in Slovene, Italian, Croatian and English languages will be accepted. The Editorial Board reserves the right to have them linguistically revised and corrected.

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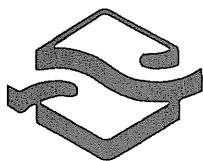
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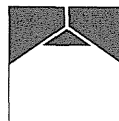
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